UNITED STATES COMMISSION OF FISH AND FISHERIES.

PART II.

REPORT

OF

THE COMMISSIONER

FOR

1872 AND 1873.

A—INQUIRY INTO THE DECREASE OF THE FOOD-FISHES.
B—THE PROPAGATION OF FOOD-FISHES IN THE WATERS OF THE UNITED STATES.

WITH SUPPLEMENTARY PAPERS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1874.

UNITED STATES COMMISSION OF FISH AND FISHERIES,

Washington, February 15, 1873.

GENTLEMEN: In compliance with the order of Congress I transmit herewith my report for 1872–'73 as United States Commissioner of Fish and Fisheries, embracing: first, the result of inquiries into the causes of the decrease of the food-fishes of the sea-coast and lakes of the United States; and, secondly, the history of the measures taken for the propagation of food-fishes by stocking the rivers and lakes with shad, salmon, and other valuable species.

Very respectfully, your obedient servant,

SPENCER F. BAIRD,

Commissioner.

Hon. SCHUYLER COLFAX,

President of the United States Senate; and

Hon. J. G. BLAINE,

Speaker of the House of Representatives.

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ACCOMPANYING PAPERS.

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ERRATA.

Page lix, for "*Pomolobus mediocris*," read "*Pomolobus pseudo-harengus*."

Page 6, in total of "hard fish," for "13,640,927," read "13,630,427."

Page 300, for "Waskeag," read "Naskeag."

Page 308, for "below the harbor of Camden," read "in the harbor of Camden."

Page 315, in the "summary" for 1863, instead of "9.8," read "10.3."

Page 319, the summary of aggregate weights should have been omitted entirely, and for mean of average weights, "10.5," read "13."

Page 331, for "ration of grilse," read "ratio of grilse."

Page 541, the claim that a literally dry method of artificial impregnation is an American discovery is an error.

Page 546, the claim that the New York State hatching-house first used wire trays for hatching is an error, as they were first used by E. A. Brackett, of Massachusetts. (See Rept. Mass. Comrs., 1868, p. 17.)

Page 609, the quotation-marks at the beginning and close of the last paragraph should have been omitted.

Page 735, for "invaluable," read "without value."

REPORT OF THE COMMISSIONER.

The present report embraces two distinct subjects: first, the result of inquiries entered upon for the purpose of ascertaining whether any decrease has taken place in the food-fishes of the sea-coast and lakes, as alleged, and, if so, what are the causes and what legislative and other measures may be necessary to remedy the evil; secondly, the history of the measures adopted, up to July, 1873, for multiplying the food-fishes of our rivers and lakes and for transferring them to new localities, with a view of increasing the food-resources of the United States and cheapening the price of provisions.

A—INQUIRY INTO THE DECREASE OF FOOD-FISHES.

1.—PRELIMINARY STEPS.

For some years past it has been alleged that the food-fishes of the eastern coast of the United States have been decreasing in number, and the attention of the General Government was called to the subject, with a view, if possible, of ascertaining the causes and suggesting a practicable remedy.

Responding to the appeals made from numerous quarters, and for the purpose of settling the question as to the facts, a resolution was passed by Congress on the 9th of February, 1871, directing the President to appoint some one of the civil officers of the Government competent to the task, to serve, without salary, as Commissioner of Fish and Fisheries.

The resolution further directed that it should be the duty of the Commissioner to prosecute the necessary inquiries, with a view of ascertaining whether any and, if so, what diminution in the number of food-fishes of the coast and lakes of the United States had taken place; and to determine what were the causes of the same, and to suggest any measures that might serve to remedy the evil. The heads of the Executive Departments of the Government were instructed at the same time to render the Commissioner such assistance as might lie in their power.

2.—INVESTIGATION IN 1871.

Having been appointed, by the President, Commissioner of Fish and Fisheries under this law, in the spring of 1871 I proceeded, by permission of Professor Henry, Secretary of the Smithsonian Institution, to carry out the inquiry thus authorized and directed, spending the summer of 1871

in this research, and establishing my headquarters at Wood's Hole, Mass., in Vineyard Sound, one of the regions most interested in the inquiry. With the assistance of several eminent specialists, particularly of Prof. A. E. Verrill, Prof. Theodore Gill, and Mr. S. I. Smith, I made an exhaustive inquiry into the subject, with all the means at my command. The results of my labors and of those of my associates have been presented to Congress in the form of a voluminous report, to which reference is suggested for further particulars.

The fish to which attention was more particularly directed during this first year were the blue-fish, scup, tautog, sea-bass, striped bass, and menhaden.

The opportunities furnished by the possession of a very perfect outfit of apparatus for the research in question were embraced to prosecute a general inquiry into the natural history of the deep seas along the coasts of the United States, as it was thought that the history of the fishes themselves would not be complete without a thorough knowledge of their associates in the sea, especially of such as prey upon them or constitute their food. It is well known that the presence or absence of particular forms of animal life in certain localities determines the occurrence of many kinds of fish; and it was thought best to make an exhaustive inquiry in this direction.

The temperature of the water taken at different depths, its varying transparency, density, chemical composition, percentage of saline matter, its surface and under currents, and other features of its physical condition, were also carefully noted, as likely to throw more or less light upon the agencies which exercise an influence upon the presence or absence of particular fishes; in other words, the object in view was to make as complete explorations of the physical, natural, and economical features of the sea as those which have been attempted for the Western Territories, under successive congressional appropriations, by Doctor Hayden, Lieutenant Wheeler, and others; the same warrant for an exhaustive research being thought to exist for the one as for the other, especially in view of the fact that the economical results to flow from a satisfactory solution of the various problems connected with the fisheries, might safely be considered as even more profitable in their immediate yield and availability than those to arise from the territorial survey.

Finally, large collections of specimens of natural history were gathered for the National Museum, embracing duplicates in great number for distribution to the various scientific and educational establishments of the country.

3.—INVESTIGATIONS IN 1872.

In arranging for the work of the Commission in 1872, it was thought best to spend the season on the Bay of Fundy, for the purpose of making an especial study of the fish and fisheries belonging to that portion of Maine and the British provinces; and, the necessary leave of absence

having again been obtained from Professor Henry, I proceeded to Eastport, in Maine, as a convenient point from which to prosecute my inquiries, arriving there on the 19th of June. I carried with me all the apparatus necessary for my work, and as soon as possible entered upon the investigation as to the present condition of the fisheries.

I succeeded in obtaining a great deal of information from persons resident in the town and vicinity, connected more or less with the fisheries; especially from Capt. U. S. Treat, of Treat's Island, Mr. William J. Odell, Mr. C. H. Dyer, Mr. Bucknam and others, of Eastport, Capt. Robinson Owen, of Campobello, &c.

It gives me very great pleasure to acknowledge the courtesies of the Department of Marine and Fisheries of the Dominion of Canada during the investigations prosecuted in the time mentioned. Before proceeding to Eastport, I addressed the Hon. Peter Mitchell, minister of the department, stating my objects, and asking for some form of document by which I might be accredited to the official fishery authorities of the Dominion, not only to prevent any interference on their part, but to secure their co-operation and assistance. This was promptly supplied, and authority granted to capture fish by any desired method, whether in accordance with the laws of the dominion or not, all the subordinate officers of the department being at the same time required to render me whatever help I might demand.

From this document, as well as from personal letters furnished by Mr. William F. Whitcher, commissioner of the Dominion fisheries, and by Mr. William H. Venning, inspector of fisheries, Saint John, New Brunswick, I received much benefit. I am also under obligations for assistance to Mr. W. B. McLaughlin, fishery-overseer at the Southern Head, Grand Manan, especially in connection with the investigation of the herring-fisheries in that vicinity.

Desirous of making a complete collection of the different *Salmonidæ* of America, for the purpose of more accurately defining their geographical distribution and of determining their comparative character, I made my wishes known to the Department of Marine and Fisheries, and instructions were at once forwarded to its officers throughout the Dominion to meet my wants. In accordance with these instructions I have already received numerous specimens of great importance to the inquiry, and which will aid considerably in accomplishing the object referred to. Several interesting communications from these officers will be found on pages 80, 81, and 82.

Here, as at Wood's Hole, I had the co-operation of Prof. Verrill, of Yale College, who kindly undertook the supervision of the investigations into the invertebrate fauna of the Bay of Fundy, with the assistance especially of Mr. S. I. Smith, Mr. O. Harger, Professor Todd, Professor Rice, &c., while Prof. D. C. Eaton took charge of the subject of the algæ. The labors connected with the fishes of the region were prosecuted with the help more especially of Prof. Theodore Gill, Mr.

G. Brown Goode, and Dr. E. Palmer. The facilities I was able to furnish at Eastport, as at Wood's Hole, induced a large number of scientific gentlemen to spend the greater part or the whole of the active season with the Commission. Among those who were present during some portion of this period may be mentioned the following:

BRITISH POSSESSIONS.....	*W. H. Venning*, of Saint John; inspector of fisheries of New Brunswick and Nova Scotia.
	Capt. N. B. Beckwith, ot Hantsport, Nova Scotia.
	Walter B. McLaughlin; overseer of fisheries, Southern Head, Grand Manan.
	George A. Boardman, of Saint Stephen, New Brunswick.
MAINE....................	*E. M. Stilwell*, of Bangor; fish-commissioner of Maine.
	O. C. Stanley, of Dixfield; fish-commissioner of Maine.
	Charles G. Atkins, of Bucksport; in charge of United States salmon-breeding establishment.
	Charles H. Fernald, of Orono; professor of natural history in the Maine State College.
NEW HAMPSHIRE.........	*Livingston Stone*, of Charlestown; in charge of United States salmon-hatching establishment on the McCloud River, California.
MASSACHUSETTS	*N. S. Shaler*, of Cambridge; assistant in the Museum of Comparative Zoology.
	T. Sterry Hunt, of Boston; professor of geology, Massachusetts Institute of Technology.
	Gurdon Saltonstall, of Boston; collector for the Boston Society of Natural History.
	James H. Emerton, of Boston; assistant in the Boston Society of Natural History.
CONNECTICUT..............	*N. S. Rice*, of Middletown; professor of natural history, Wesleyan College.
	G. Brown Goode, of Middletown; curator of the Museum of Wesleyan College.
	A. E. Verrill, of New Haven; professor of zoology, Yale College.
	Daniel C. Eaton; professor of botany, Yale College.
	W. D. Whitney; professor of Oriental literature, Yale College.

	S. I. Smith, *J. K. Thatcher*,	assistant teachers of zoology in Yale College.
	O. Harger; assistant in Yale Museum.	
	John B. Isham, *George W. Hawes*, *T. Mitchell Prudden*,	students of Yale Scientific School.
	Talcott H. Russell, of New Haven.	
NEW YORK	*H. E. Webster*, of Schenectady; professor of natural history, Union College.	
	Charles Pond; student of natural history, Union College.	
	H. A. Ward, of Rochester; professor of natural history, Rochester University.	
OHIO	*Rev. J. G. Fraser*, of East Toledo.	
	Robert Brown, jr., *John Davis, M. D.*, *Rev. A. E. Taylor*, *Richard Folsom*,	committee on marine aquaria for the Cincinnati Industrial Exposition, September and October, 1872.
IOWA	*J. E. Todd*, of Tabor; professor of natural science, Tabor College.	
DISTRICT OF COLUMBIA	*Theodore Gill*, Smithsonian Institution, Washington.	
	Edward Palmer, of Washington.	
	A. G. Seaman, Agricultural Department, Washington.	

Among these visitors, Mr. Robert Brown, Dr. John Davis, Rev. A. E. Taylor, and Mr. Richard Folsom came for the purpose of obtaining living specimens of marine zoology with which to stock an aquarium at the Cincinnati Industrial Exposition.

In the course of the summer, the fish-commissioners of Maine, E. M. Stilwell and O. C. Stanley, spent several days with me, in company with Mr. Atkins, during which time the subject of restocking the waters of the State with salmon was discussed, and an understanding entered into with them in regard to hatching such eggs of this fish as I might be able to allot to the State from the stock owned by the United States. Mr. Livingston Stone also, prior to his departure for California for the purpose of securing eggs of the Sacramento salmon, visited me in order to arrange the details of his operations.

In continuation of the courtesies previously extended, the Treasury Department instructed Capt. D. B. Hodgden, in command of the revenue-cutter Mosswood, to render me such assistance as he could without interfering with his regular duties; and to him and his officers I am under many obligations for the cordiality and readiness with which they carried out these orders. Without the help of the cutter, I should have been able to make a few only of the researches

and investigations which have proved of great service in the inquiry intrusted to my charge.

In the course of the summer I visited the British provinces, passing through Saint John, Digby, Annapolis, Halifax, Pictou, Prince Edward Island, Shediac, and Fredericton, with a view of ascertaining the present condition of the fisheries, the nature of the regulations concerning them, as well as the various methods for carrying them on, and I am particularly indebted for valuable assistance and information to Mr. William Jack, of Saint John; to Dr. J. B. Gilpin and Mr. J. Matthew Jones, of Halifax; and to Mr. Dunn, the United States consul, and Mr. J. C. Hall, merchant of Charlottetown.

My inquiries in reference to the herring and other fisheries of the coast would not have been complete without a visit to Grand Manan, and especially, the southern extremity, known as Southern Head, and well known to be the great spawning-ground of the majority of the herring entering the Bay of Fundy. With the aid of a letter from Mr. William F. Whitcher, the Commissioner of Fisheries at Ottawa, to Mr. Walter B. McLaughlin, in charge of the spawning-grounds, I was enabled to obtain a great amount of very valuable information in regard to this interesting locality. To Mr. Simeon F. Cheney, of Nantucket Island, Grand Manan, I am also much indebted for services rendered.

The fact that particular portions of our sea-coast are frequented by the herring during their spawning-season, while others, apparently equally eligible, remain unvisited by them, induced me to undertake a careful investigation of ocean temperatures; and, with the assistance of Captain Hodgden, of the revenue-cutter, I was enabled to secure, through the use of the Casella-Miller deep-sea thermometer, many records of the temperature of the bottom waters at different parts of the Bay of Fundy, as well as of the surface. These are considered of very great importance in solving the various problems referred to. *

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*A movement in the same direction was subsequently undertaken by the Scottish Meteorological Society, having for its object the determination of the question as to how meteorological conditions of air and water influence the herring-fishery, an industry of the first importance to the inhabitants of Scotland; the inquiry having been suggested by the Marquis of Tweeddale, president of the society, in a letter transmitted on the 30th of January, 1873.

A committee was appointed, and on the 2d of July reported the progress made, when, although no very positive results were announced, enough was adduced to show the eminent propriety of the investigation and the probability of attaining important generalizations. (Journal of the society, July, 1873, 60.)

The inquiry was restricted at first to the east coast of Scotland, and to pond-fishing districts therein, viz, Wick, Buckie, Peterhead, and Eyemouth, the last including the fishing-ports of Dunbar and Eyemouth, Berwick, and North Sunderland. Copies of the weekly returns sent to the fishery-board from these districts during July to September, the season of the herring-fishing for that part of Great Britain, for six years, beginning with 1867 and ending with 1872, giving the catch per week, the number of

Having been so fortunate as to interest Professor Peirce, of the Coast-Survey, in the general inquiry intrusted to me by Congress, I received, under his instructions, from Captain Patterson the proffer of the aid of that branch of the service in pursuing such investigations as related in any way to its own objects; and as the physical and natural history of the various banks off the New England coast constituted a common bond of interest, it was determined by the Superintendent to fit out the steamer Bache to make surveys on George's Banks, one of our best fishing-grounds. I was authorized to put on board two experts in the line of marine zoology, for the purpose of prosecuting the necessary inquiries; and having selected Mr. S. I. Smith and Mr. Harger, these gentlemen presented themselves at Provincetown, as the place of rendezvous, at the appointed time. While certain needed repairs of the vessel were being completed, these gentlemen in the interval visited Eastport and entered into the general inquiries prosecuted in the Bay of Fundy. They, however, returned to Provincetown when the Bache was ready to take them on board; and although beginning their work so late in the season, as to be interfered with by storms and unfavorable weather, they succeeded in securing many valuable results, a report of which will be presented hereafter.

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boats out in each district, were extracted from the reports, and an average of these six years calculated at several of the stations. These were finally compared day by day with two series of sea-temperatures; one taken off Harris, and the other near Edinburgh.

The temperature of the sea was found to rise very rapidly about the middle of July; and to keep oscillating slightly about a uniform temperature of 56° until the 13th of August, when it rapidly rose to the annual maximum, namely, 57°.2, and ranged relatively high until the first of September. This period of highest annual temperatnre, namely, from the middle of July to the first of September, was found to be coincident with the fishing-season in the northern districts of Scotland; and the period when the temperature rises to the absolute maximum is further coincident with the date of the largest catches during the fishing-season. The committee, however, consider it premature to lay great stress on the striking coexistence of these facts, since it is impossible, without further statistics, to say whether these relations are of a permanent character. The fishing-season did not begin until the sea-temperature had risen to about 55½° in July, nor did it continue after it had fallen below 55½° in September.

An important omission in these tables is, that they do not show whether they indicate the surface or bottom temperature of the sea; the difference in this respect being very appreciable. Another omission is, as to the relation between the spawning-season of the herring and their shoreward movement. Along the coast of the United States, the great spawning-ground of the sea-herring is off the southern end of Grand Manan, where the surface and bottom temperatures sometimes differ at the spawning-season by as many as five or six degrees.

An important relation was also observed by the committee between the exceptional atmospheric temperatures and the migrations of the herring, the fishing-season beginning much later in the year, when the summer-temperatures are low, than when they are high. As regards the relation between barometric observations and the fisheries, it appears that during the periods when good or heavy catches were taken, in a great majority of cases the barometer was high and steady, the winds light or moderate, and electrical phenomena wanting; when the captures were light, the observa-

4.—CORRESPONDING RESEARCHES OF OTHER NATIONS.

A few years previous to the movement on the part of the United States in the establishment of a commission for the investigation of the fish and fisheries of its coast, the *Fischerei-Verein*, an association composed of several eminent naturalists, physicists, and statisticians of Germany, warmly urged upon its government the importance of prosecuting similar researches, recognizing equally with the United States that the only way of securing definite and practical results in the way of protecting and improving the fisheries was to initiate a series of thorough inquiries into the general physical and natural history of the seas.

A commission was accordingly appointed by the German government to report upon the best method of securing the desired object. A report of what was needed was presented by the commission, which invited careful inquiry into the following points: first, the depth, and character of the water, the peculiarities of the bottom, the percentage of salt and gas in the water, and the nature of its currents and temperatures; secondly, a minutely-detailed determination of the animals and plants found in the sea; and, thirdly, the distribution, mode of nourishment, propagation, and migration of the useful fishes, shells, crustaceans, &c. While this programme embraced the primary physical condi-

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tions often indicated a low barometer, strong winds, unsettled weather, and thunder and lightning.

In conclusion, the committee recommend that, in further elucidation of the subject, steps should be taken to obtain information which may lead to a solution of the following queries:

1. What determines the time of the commencement of the fishing?
2. What determines the fluctuations in the catches of herring in different districts, or in the same district on different days?
3. What causes the absence of herring during some seasons from certain districts of the coast?
4. What determines the ending of the fishing-season?

The information required demands—

1. An extension of the area examined, so as to include the Moray Firth, the Shetland, Orkney, and Hebrides Islands, and the west coast of Scotland.
2. Daily returns of the number of boats fishing and the catch.
3. The erection of self-registering sea-thermometers at different points on the coast, similar to those now in operation at Peterhead Harbor.
4. Thermometric observations taken by the fishermen themselves over the grounds fished; as it is only by the observations of numerous thermometers in continuous immersion that we can hope to obtain accurate information regarding those currents of cold and warm water round our coasts which are often found to interpenetrate each other, and which are supposed, with apparently good reason, to influence greatly the migration of the herring. It is said that the Dutch fishermen derive valuable practical advantages from a system of this kind, and there can be no doubt that favorable results might confidently be looked for if a similar system were generally adopted by our fishermen.

It is an interesting fact in the natural history of the herring that, while the season or their capture is quite definite and generally uniform at any one point, it varies on different parts of the coast; thus, on the east of Great Britain, from Shetland in the north to Flamborough Head in the south, it occurs in July, August, and September,

tions of organic life in the sea, and their variations, the final object, of course, was a practical one, namely, the determination of the facts embraced under the third head. As, however, very little was known in reference to the natural laws of distribution, &c., of the useful animals, it became necessary to investigate them from a scientific point of view; so that the primary inquiries were strictly scientific, the deductions therefrom leading to the practical end.

The initiation of the Franco-German war interfered very materially with this programme, and it was not until 1871, and nearly at the same time with the American investigations, that operations were actually commenced. The commission consisted of Dr. H. A. Meyer, Dr. K. Möbius, Dr. G. Karsten, and Dr. V. Hansen, each gentleman having charge of some special branch, and all co-operating toward the common result. Fixed stations were established at various points for the purpose of observing the variations of atmospheric conditions, the daily changes of temperature of the water, and the occurrence of special phenomena of animal and vegetable life; and for several months in the year the commission, with its assistants, was engaged in researches at sea, prosecuted upon the government steamer Pommerania, placed at its disposal, under Captain Hoffmann. Upon this work the commission has been engaged for three successive seasons, and has just published a report of its operations during the year 1871.

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and a little earlier in the north than in the south. At Yarmouth the herring-season is in October and November; off the Kentish coast, in November and December; along the south coast of England, from October to December; off Cornwall, in August and September; in the North Channel, in June and July; and in the Hebrides, May and June.

It is suggested by the Scottish committee in their report that when the periods of migration on all parts of the British sea-coast will have been calculated as closely as in Scotland, these will be found to bear a critical relation to the annual epochs of the temperature of the sea. This gives a renewed importance to the inquiries undertaken by the United States Signal-Service and the Fish Commission, on the American coast, in the way of determining of the sea-temperature, &c., as connected with a very important branch of our domestic industries.

In this connection we may state that the spawning-season of the herring, and the time of its catch, vary remarkably in different portions of our own coast. Thus, in parts of the Bay of Fundy and in the Gulf of Saint Lawrence, it takes place in May and June, as in the Hebrides; at the Southern Head of Grand Manan, the great spawning-ground, it occurs in September, commencing possibly in August, and extending into October; taking place later and later in the season as we proceed south. At the most southern point at which the herring is positively known to spawn, namely, off Noman's Land and possibly Block Island, this does not occur until December and January.

From this we may draw the inference that a certain minimum of temperature, rather than a maximum, is needed for the operation in question; and this occurring in the autumn, that the proper temperature is reached later and later as we proceed southward.

It is to be hoped that the temperature-observations now being made by the United States Fish Commission and by the Signal-Service may enable us to solve these problems and to co-operate with our Scottish scientific brethren in getting at the true relation between physical conditions and the movements of such important food-fishes as the herring, mackerel, cod, &c.

5.—CONCURRENT ACTION OF THE UNITED STATES SIGNAL-SERVICE.

So far the only nations that have undertaken investigations into the fish and fisheries of their coasts in a thoroughly scientific manner are Norway, Germany, and the United States; and it is with much satisfaction that we can claim at least an equal degree of completeness, in the inquiry, to the others. While no permanent stations have been established on the coast directly under the authority of the United States Fish Commission, the hearty co-operation of General Myer, the Chief Signal-Officer, has rendered this unnecessary. Meteorological observations are, of course, made regularly at all the signal-stations along the coast and on the lakes, and in addition to these the Chief Signal-Officer has directed that a daily record be made of the temperature of the water at the surface and at the bottom, and that copies be sent to the Fish Commission. The examination of these records has already developed many interesting facts, and promise important generalizations of direct practical application to the fisheries.

It is well known that in Europe the fisheries are under the immediate control of the authorities, and that in Norway, especially, such is the attention given to the fullest development of this interest, that the government causes information to be furnished by telegraph of the approach of the herring and cod to the shores, and in regard to their subsequent movements, by this means enabling the entire fishing-fleet at a given point at once to take advantage of the facts, instead of depending upon casual information, which is frequently incorrect, moreover the facts are frequently willfully suppressed by parties who desire to enjoy a monopoly.

General Myer, the chief Signal-Officer of the Army, in charge of the Government system of weather telegraphy, desirous of rendering his department serviceable in the highest degree to the interests of the country, in a letter dated November 21, 1872, invited suggestions in regard to the utilization of the system of telegraphic signals for the benefit of the fisheries. It gave me pleasure to call his attention to the points just referred to in connection with the Norwegian government, and to suggest that much might be done by instructing the signal-officers to keep watch of the facts in regard to the occurrence of herring, mackerel, cod, and other coast-fishes off the shores, and to cause these facts to be promptly communicated to the newspapers.

I also urgently advised the establishment of a signal-station at Eastport, in Maine, as being the center of the United States herring fisheries, and a place where the information which could be furnished by such a station would be of the utmost value. This includes not only the announcement as to impending changes of the weather generally, such as any seaman would desire to be made acquainted with for the purpose of determining his movements, but has especial reference to the trade in frozen herring. During the winter-season, herring of the finest quality are captured in Passamaquoddy Bay and adjacent portions of the coast,

in gill-nets, and if the weather is sufficiently cold to freeze them they can be shipped to western ports, where they meet a ready sale. In warm weather, however, this does not take place, and large catches are frequently lost. It is, therefore, of the highest importance to be able to anticipate by a few days the nature of the weather. Thus, in a warm season, during which a haul could not be frozen for export, but a cold turn likely to supervene, if timely notice were given to the fishermen, they would be ready to take advantage of the condition of the weather, making their haul and having the fish ready for transportation at the proper time. If, on the contrary, during a cold spell, a warm period be likely to succeed, the fishermen could be warned, and, by avoiding the making of a catch that could not be sold, save themselves from loss. Such applications of information, furnished by the signal-station at Eastport, have already been made, and will doubtless be multiplied during future seasons. The dealers at Chicago and at other points on the lake find a most valuable advantage in the signals of approaching storms, and increase the amounts of fresh fish ordered from the fisheries in accordance with the fact, knowing that the supplies will be cut off by the impossibility of lifting the nets in bad weather.

I am happy to say that General Myer took a favorable view of the suggestions made to him, and promptly established a signal-station at Eastport, which has already more than met the anticipations of its usefulness to the fisheries of the Bay of Fundy.

The recent location of a series of signal-service stations along the coast of the United States, in connection with the life-saving establishments, promises the means of using the telegraph in aid of the fisheries to a very great degree. The movement of fishes on the coast, already referred to, can thus be readily ascertained and communicated from the Washington office to parties interested.

6.—CONCLUSIONS AS TO DECREASE OF COD-FISHERIES ON THE NEW ENGLAND COAST.

Of all the various fisheries formerly prosecuted directly off the coast of New England, north of Cape Cod, the depreciation in that of the cod appears to be of the greatest economical importance. Formerly the waters abounded in this fish to such an extent that a large supply could be taken throughout almost the entire year along the banks, especially in the vicinity of the mouths of the larger rivers. At that time the tidal streams were almost choked up with the alewives, shad, and salmon that were struggling for entrance in the spring, and which filled the adjacent waters throughout a great part of the year.

As is well known, the erection of impassable dams across the streams, by preventing the ascent of the species just mentioned to their spawning-grounds, produced a very great diminution, and almost the extermination, of their numbers; so that whereas in former years a large trade could be carried on during the proper season, now nothing would be gained by the effort.

Of late the attention of the legislatures of the New England States has been called to this fact, and to the importance of restoring their fisheries, and a great deal has been already accomplished toward that end. Unfortunately, however, the lumbering interest in Maine, and the manufacturing in New Hampshire and Massachusetts, are so powerful as to render it extremely difficult to carry out any measures which in any way interfere with their convenience or profits; and notwithstanding the passage of laws requiring the construction of fish-ways through the dams, these have either been neglected altogether, or are of such a character as not to answer their purpose. The reform, therefore, however imperatively required, has been very slow in its progress, and many years will probably elapse before efficient measures will be taken to remedy the evils referred to.

It would, therefore, appear that while the river-fisheries have been depreciated or destroyed by means of dams or by exhaustive fishing, the cod-fish have disappeared in equal ratio. This is not, however, for the same reason, as they are taken only with the line, at a rate more than compensated by the natural fecundity of the fish. I am well satisfied, however, that there is a relation of cause and effect between the present and past condition of the two series of fish; and in this I am supported by the opinion of Capt. U. S. Treat, of Eastport, by whom, indeed, the idea was first suggested to me. Captain Treat is a successful fisherman, and dealer in fish on a very large scale, and at the same time a gentleman of very great intelligence and knowledge of the many details connected with the natural history of our coast-fishes, in this respect worthily representing Captain Atwood, of Provincetown. It is to Captain Treat that we owe many experiments on the reproduction of alewives in ponds, and the possibility of keeping salmon in fresh waters for a period of years. The general conclusions which have been reached as the result of repeated conversations with Captain Treat and other fishermen on the coast incline me to believe that the reduction in the cod and other fisheries, so as to become practically a failure, is due, to the decrease off our coast in the quantity, primarily, of alewives; and, secondarily, of shad and salmon, more than to any other cause.

It is well known to the old residents of Eastport that from thirty to fifty years ago cod could be taken in abundance in Passamaquoddy Bay and off Eastport, where only stragglers are now to be caught. The same is the case at the mouth of the Penobscot River and at other points along the coast, where once the fish came close in to the shore, and were readily captured with the hook throughout the greater part of the year. That period was before the multiplication of mill-dams, cutting off the ascent of the alewives, shad, and salmon, especially the former. The Saint Croix River was choked in the spring with the numbers of these fish, endeavoring to ascend; and the same may be said of the Little River, the outlet of Boynton's Lake, about seven miles above Eastport. The lake in question is one of considerable size, and was visited by

immense numbers of alewives, which could be dipped out, to any extent, on their passage upward, while the waters of the adjacent bay were alive with the young fish on their return.

The fish themselves enter the waters of the streams in May or June, and return almost immediately after spawning, to the sea. But they may be taken by the drift-nets along the shores as early as March and April; and, indeed, it is quite probable that the whole period of their abode in the salt-water is spent adjacent to the rivers in which they were born. The young come down from the ponds in which they are hatched, from August to October, keeping up a constant stream of the young fish. In this way a supply of alewives was to be met with throughout the greater part of the year, and nearer the coast they furnished every inducement for the cod and other ground fish to come in-shore in their pursuit.

It is true that the sea-herring is also an attraction to these fish, and probably but for their presence our pollack, haddock, and hake-fisheries would be greatly diminished. Nevertheless, the alewife appears to be more attractive as a bait, and furthermore the sea-herring are less constantly on the coast, especially in-shore, occurring as they do at stated intervals, when they come in from the deep sea to spawn. It is possible, too, that they are less easily captured by the cod, since they swim nearer the surface than the alewives. Corroboration of this idea is furnished in the testimony of Mr. W. B. McLaughlin, of Southern Head, Grand Manan. This gentleman informs me that the only stream in the island which ever furnished alewives to any extent was Seal Cove Creek, which discharges to the east of the southern extremity of Grand Manan, and into which these fish entered in immense numbers in the spring. At that time cod, haddock, and pollack, as well as halibut, were taken in great abundance in Seal Cove Sound, between Hardwood Cove, on Wood Island, and Indian or Parker's Point, on the main island. They were to be met with during the greater part of the year especially from May to January; and the fishery in the channel-way within a quarter of a mile of the shore was really more productive than on the banks much farther out to sea.

Although still a young man, Mr. McLaughlin recollects the capture of these fish; and, indeed, as a mere boy enjoyed the sport within a very short distance of his father's house. Soon after that time a dam was built across this stream about 200 yards above its mouth, cutting off entirely the upward passage of the alewives, and by a remarkable coincidence, if it be nothing more, the cod-fishery in question diminished very soon after, and in a few years ceased almost entirely, so that up to the present time there are not enough cod in those waters to repay the experiment of attempting to catch them. A few alewives still find their way up to the foot of the dam, but in such small numbers as to make it often doubtful whether there are any there or not.

The other fishing-grounds about Grand Manan are farther out to sea,

at the northern end of the island, where there are no alewives, and where herring appear to be the principal food, although the variation in the abundance of these in different seasons appears to have an important bearing upon the number of hake and cod.

If these conclusions be correct—and I am quite satisfied of their general validity—we have, for the efforts made to establish fish-ways in the rivers of Maine, New Hampshire, and Massachusetts, a much more weighty reason than that of merely enabling a few salmon to enter the streams in order to permit their capture while on their way.

Whatever may be the importance of increasing the supply of salmon, it is trifling compared with the restoration of our exhausted cod-fisheries; and should these be brought back to their original condition, we shall find, within a short time, an increase of wealth on our shores, the amount of which it would be difficult to calculate. Not only would the general prosperty of the adjacent States be enhanced, but in the increased number of vessels built, in the larger number of men induced to devote themselves to maritime pursuits, and in the general stimulus to everything connected with the business of the sea-faring profession, we should be recovering, in a great measure, from that loss which has been the source of so much lamentation to political economists and well-wishers of the country.

As the observations in regard to the marine animals and plants of the Bay of Fundy will not be complete without referring to and including those found on the remaining shores of Maine, I defer, for the present, any report upon them such as has been made for Wood's Hole. It is proposed to devote the summer of 1873 to researches in Casco Bay and the adjacent waters, and also, with the aid of the United States Coast-Survey steamer Bache, to examining the waters between the Maine coast and Cape Cod; and it will be more satisfactory to present the results of the two years' work in one account.

7.—INVESTIGATIONS IN 1871 AND 1872 ON THE GREAT LAKES.

The act of Congress specially directed that investigations should be conducted on the great lakes, of the same kind as those ordered for the coasts of the United States; and, under this provision, Mr. James W. Milner was appointed assistant commissioner, with instructions to collect as reliable data as possible on the following points: the evidences of decrease in the numbers of the food-fishes; and, this fact established, to ascertain its causes, and what practicable methods may be applied for their restoration. It was determined to confine the inquiry for the first season to one lake, and to give it a thorough examination. Lake Michigan, having the longest line of shore within the United States and the largest number of fisheries, was selected as the region for the investigation.

Instructions were also given him to make full collections of all forms of life found in the waters, and to take as full notes as possible on the

habits of the species; making the white-fish, the most valuable food-fish of the lakes, the principal object of attention and efficient action for their restoration.

On the 13th of April, 1871, the first visit to the fishing-shores was made, and it became evident from the first, that to obtain any definite knowledge of the amount of decrease, it would be necessary to make the entire circuit of the lake. The migratory habits of the fish and the tendency to entirely change their locality after a term of years, at least in the opinion of the fishermen, made it evident at once that the condition as to numbers could not be understood from any circumscribed area of shore, but that a collection of accurate statistics through a term of years for all the fishing-regions must be gathered to give satisfactory evidence as to their condition.

The southern end of the lake was visited from point to point by steamer and rail before the middle of summer, and, at the northern end, where no steamers plied, the tour was made in an open boat, the trip lasting about five weeks, the sum of the distances traveled from point to point being about six hundred miles. Seventy-one stations were visited, embracing nearly the entire number of fisheries.

Though recorded statistics in the fishing localities were rare, still good evidences were obtained of the decrease and its causes, and many interesting notes of the habits of species and their mutual relations procured. Information was constantly sought and obtained, from fishermen, dealers, and residents, on the subject of the fisheries, which was noted for use in preparing a report on the subject of the inquiry.

As on several other occasions, very important assistance was rendered by the Secretary of the Treasury, the revenue-steamer Andrew Johnson, Capt. David Evans, being instructed to afford facilities for examination of the bottom fauna of the lake. In September Mr. Milner went on board with a dredging outfit, and remained during a cruise of two weeks dredging in depths of from 30 to 144 fathoms, obtaining a full collection of invertebrate forms from the bottom and some knowledge of the temperature at those depths. The species collected were examined by Dr. William Stimpson; but soon after they were received at the Chicago Academy of Sciences, they were lost in the great fire of October.

The dredge was also used from a small boat in Torch Lake, of the Grand Traverse Region, Michigan, in 40 fathoms, and the same forms of *Mollusca*, *Mysidæ*, and *Gammaridæ* were found as in Lake Michigan.

The inquiry was renewed in the latter part of June, 1872; the region of Lake Superior was explored, collections and notes ware obtained, and similar inquiries were made with reference to numbers of fishes. Much less evidence of decrease in this lake was the result, though a marked diminution was ascertained to have taken place in certain localities.

In the autumn of 1872 nearly a million of white-fish eggs were obtained by Mr. Milner and placed in Mr. N. W. Clark's hatching-house at Clarkston, Mich., from which in the winter a large number were for-

warded to California for the waters of Clear Lake. Arrangements were also made for the hatching of salmon for the waters of Michigan and Wisconsin.

At the close of the field-work of the season, Mr. Milner visited all the prominent dealers on the chain of lakes, and obtained the amounts of their receipts of lake-fish for the year.

After the close of the distribution of the shad in 1873, Mr. Milner visited the shores of Lake Huron, and obtained a collection of its fishes. The inland locality in that region inhabited by the grayling was also examined, notes relating to its habits were obtained, and a knowledge of the facilities for obtaining the spawn acquired.

Later he proceeded to Lake Erie, and made a large collection of fishes in the vicinity of Sandusky, Ohio; and afterward at Cincinnati the species of the Ohio River were obtained.

Full details of Mr. Milner's labors will be found on page 1 of the appendix to the present report.

B—ACTION IN REGARD TO PROPAGATION OF FOOD-FISHES.

8.—INTRODUCTORY MEASURES.

It will be observed that the labors thus referred to, as authorized by the original resolution of Congress, relate only to the investigations of the facts as to an alleged decrease of the food-fishes of the sea-coast and the lakes of the United States, an inquiry into the causes of the same, and the best methods of remedying the evil.

At a meeting of the American Fish-Culturists Association, held in Albany February 7, 1872, it was for the first time suggested that measures be taken to induce the United States to take part in the great undertaking of introducing or multiplying shad, salmon, and other valuable food-fishes throughout the country, especially in waters over which its jurisdiction extended, or which were common to several States, none of which might feel willing to incur expenditures for the benefit of the others.

A committee, of which Mr. George Shepard Page was chairman, was accordingly appointed to present the subject to Congress, and to do whatever was in its power to secure the desired object. This gentleman visited Washington, and appeared before the Committee on Appropriations to urge the measure and secure its favorable action. A clause appropriating $10,000 was accordingly put into the appropriation bill for the purpose in question; but this was rejected by the House. Subsequently, however, the subject was considered by the Senate committee, who took an equally favorable view of it with the House committee, and an amendment appropriating $15,000 was introduced and carried successfully through Congress; its disbursal being placed under my charge. To the action of the association in question, therefore, the credit of the original idea and the consequent favorable action of Congress is emphatically due.

On the 13th of June a meeting was held in Boston, three days after the passage of the act, composed of the fish-commissioners of the New England States and of members of the Fish-Culturists Association, at which the general problem as to the best method of carrying the act of Congress into effect was presented. After full deliberation, it was recommended that the services of Messrs. Green and Clift be secured for the planting of shad in the Mississippi River and its tributaries, and that means be furnished to Mr. Atkins, of Bucksport, Me., to enable him to enlarge his operations on the Penobscot River, and to Mr. Stone for similar labors on the Sacramento.

In reference to shad, it was thought that they might even live comfortably the whole year round in the great lakes, with the exception of a short run up the tributary rivers for the purpose of spawning. As to whether they would push their way up from the Gulf of Mexico to the headwaters of the main tributaries of the Mississippi River was, of course, a problem which could not be solved without experiment.

The proceedings of this meeting will be found in the appendix to the present volume.

9.—PROPAGATION OF SHAD IN 1872.

Little time was to be lost in carrying out the suggestions with reference to shad, as the appropriation was not available until the 1st of July, and the season during which the eggs could be successfully hatched lasted but a few days beyond that period.

Both Messrs. Green and Clift, however, undertook to do what they could, and worked with great energy. In addition to the large number of eggs introduced by Mr. Green, in behalf of the State of New York, into the Hudson River, Oneida Lake, Lake Champlain, and Genesee River, he furnished 50,000 fish for Lake Champlain to the commissioners of Vermont, and, in behalf of the United States Government, placed 30,000 in the Alleghany River at Salamanca, N. Y., and 25,000 in the Mississippi River, a few miles above Saint Paul, Minn.

The later period at which the shad spawn in the Connecticut enabled Mr. Clift to secure a larger margin of time for his arrangements; and, by the kind assistance of the commissioners of the State of Connecticut, he succeeded in procuring, from the State hatching-house at Holyoke, Mass., a sufficient number for his purpose. Mr. Clift started, on the 2d of July, with several hundred thousand young fish, filling nine eight-gallon cans. Of these, a portion, estimated at 200,000, were placed in the Alleghany at Salamanca, and a like number in the Cuyahoga, in the White River at Indianapolis, Ind.; the remainder were carried direct to Denver, in Colorado; and, on the 7th of July, introduced 2,000 in number into the Platte.

Very valuable assistance was rendered in this experiment by the

express companies, especially the Adams and the American and Merchants' Union. Without the help, of special instructions to their agents to assist Messrs. Green and Clift, it would have been difficult to accomplish the object in view.

Acknowledgments are also due to the commissioners, both of New York and Connecticut, for placing their hatching-establishments at the disposal of the United States in order to furnish the necessary number of eggs.

Concurrently with the operations on the part of the United States, the commissioners of both New York and Connecticut were industriously engaged during 1872 in continuing experiments previously instituted in regard to stocking the waters of their respective States with shad, and incredible numbers of young fish have been introduced. Thus in New York, under the efficient direction of Mr. Seth Green, nearly 7,000,000 shad were released in the waters of the State, while the extraordinary number of 92,065,000 young fish is reported by Dr. Hudson to have been turned into the waters of the Connecticut. Dr. Edmunds, commissioner of Vermont, also obtained 50,000 young fish from Mr. Green, which were placed inBurlington Bay, Lake Champlain.

Whether shad can live permanently in fresh water, and maintain those characteristics of flavor and size which give them such a prominence, and whether they can be established in the Mississippi Valley are problems not yet solved; but the results to be obtained, in the event of its possibility, are of such transcendant importance in relation to the food-supply of the country, and the cost of the experiment so very trifling, that it would be inexcusable not to attempt it.

11.—PROPAGATION OF MAINE SALMON IN 1872.

More time was allowed for satisfactory arrangements in regard to the propagation of salmon than of shad, because of the much later period in the year when they spawn; this in the common salmon (*S. salar*) not taking place until the end of October or the beginning of November, and varying with the locality.

In compliance with the suggestion of the meeting at Boston, I had an interview with Mr. Charles G. Atkins at Bangor, and ascertained the probable degree of expansion that he could give to his operations at Bucksport, on the Penobscot River, with additional funds.

The method devised by him consists in obtaining mature fish as they come up the river and are taken by the fishermen, placing them in a pen situated in a large pond of about 150 acres, and keeping them there until the season of reproduction, and then securing the spawn, and, after impregnating it, hatching it in a suitable hatching-house.

The only method of obtaining salmon in sufficient numbers was to offer the full market-price to the fishermen for all they may deliver alive to the hatching-establishment. About six hundred fish were thus obtained during the summer. But little mortality occurred among these fish, and, on the 28th of October, Mr. Atkins and his assist-

ants commenced taking the spawn, securing about 1,560,000 eggs. These were brought forward in the hatching-house at Bucksport until February. During that month and March they were distributed to other hatching-houses in different parts of the country in order there to be fully developed.

The experiment in regard to the Bucksport salmon-hatching establishment was initiated in New York on the 17th of April, 1872, by an agreement of several parties to contribute funds to a given amount, the division of the spawn to be made in the same ratio. The subscriptions were as follows:

E. M. Stilwell and H. O. Stanley, jr., for the State of Maine.....	$500
E. A. Brackett, for the State of Massachusetts................	1,000
I. H. Barden, for the State of Rhode Island....................	400
W. M. Hudson, for the State of Connecticut....................	1,000
W. Clift, for Poquonnoc Fish Company........................	300

These gentleman kindly consenting, I supplied, from the funds at my disposal, the means to greatly enlarge the scale of operations, and received a pro-rata share of the eggs. The full history of the entire enterprise connected with the taking of the eggs in 1872, and their distribution in 1873, will be found in Mr. Atkins's report, beginning page 226 of the present volume.*

11.—PROPAGATION OF THE RHINE SALMON IN 1872.

The possible contingency of failure in Mr. Atkins's experiment induced me to look to other sources for an additional supply of eggs; but I was unable to make any arrangement in America for that purpose. In consequence of the scarcity of fish, it was impossible to organize upon other salmon-rivers of Maine the experiment that Mr. Atkins had begun on the Penobscot; and the regulations of the Dominion authorities in regard to gravid salmon and their eggs are such as to preclude the idea of looking across the borders for assistance.

The Canadian government has, it is true, a hatching-establishment at Newcastle, on the north side of Lake Ontario, near Toronto, and has occasionally allowed a surplus, left after it has supplied its own wants, to be sold to parties in the United States. The charge, however, being $40 a thousand, (in gold,) was considered excessive, and the only alternative left was to look to Europe, where the streams emptying into the North Atlantic abound in precisely the same species. Under these circumstances, and after much consideration, I decided to obtain what I wanted from the Rhine, the fish of that river being famous for their excellence and size. I accordingly applied to the secretary of the *Deutsche Fischerei-Verein* at Berlin, inquiring whether any eggs could be procured from the government fish-breeding establishment at Hüningen. To my gratification, I was informed that, on the represen-

*On the Salmon of Eastern North America and its Artificial Culture, p. 226.

tation of the *Verein* to the German government, it had been decided that 250,000 eggs should be presented to the United States at the proper time, all packed and ready for transmission, provided I would agree to have them transported to a point of shipment under the care of an experienced operator. To this, of course, I gladly agreed, and named Mr. Rudolph Hessel, of Offenburg, an eminent fish-culturist and highly esteemed correspondent, from whom I had already derived much valuable information, to take charge of that duty. Articles by this gentleman upon the salmon of the Danube River, (*Salmo hucho*,) the breeding of the cyprinoid fishes, &c., will be found in the appendix to his report.*

The following letters on this subject were received from the authorities in Germany:

[Translation.]

BUREAU OF THE DEUTSCHE FISCHEREI-VEREIN,
Berlin, June 11, 1872.

In consequence of your letter of the 15th of May, addressed to Professor Peters, of this city, in reference to the acquisition of salmon-eggs for your Government, we have applied to the superintendent of the fish-culture establishment at Hüningen, and have received his reply, of which we inclose a copy.

Placing you thus in possession of the facts in the case, we beg that you will favor us as speedily as possible with a reply as to whether your Government is ready to assume the cost of the transportation of 250,000 salmon-eggs.

MANARD.

DR. SPENCER F. BAIRD, *Washington.*

[Translation.]

HÜNINGEN, *June* 7, 1872.

On receipt of your letter I placed myself immediately in communication with the circle president in reference to the conditions under which the establishment could supply salmon-eggs to the American Government. On my proposition, it was agreed that, in any event, the eggs should be furnished free of expense, although it is not possible to supply "several millions." As the salmon-eggs are intended, in the first place, for Germany alone, the establishment could not pledge itself to supply more than 250,000 at most, and this only on the condition that the necessary care be exercised in their transportation. It is an indispensable condition that the eggs shall be taken from here by a special messenger to Havre or Cherbourg, so that they may be secured against heating during the journey. Arrangements must also be made for their preservation on the steamer in a uniformly cool place, and for their reception in New York by an expert in such matters. The doublepacking of a quarter of a million of salmon-eggs will require at least thirty boxes, each weighing about fifteen pounds; so that the whole will weigh nearly five hundred pounds and occupy a considerable space.

HAACK, *Director.*

HERR MANARD.

[Translation.]

IMPERIAL FISH-BREEDING INSTITUTION,
Hüningen, near St. Louis, Alsace, August 13, 1872.

HONORABLE SIR: I have been asked by the Bureau of the German Fishery Association to write directly to you in reference to the Rhine salmon-eggs to be sent to America.

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*The Salmon of the Danube, or the Hucho, (*Salmo hucho*,) and its Introduction to American Waters, p. 161; also Method of Treating Adhesive Eggs of Certain Fishes in Artificial Propagation.

The first eggs are usually obtained by the middle of November, but in such small numbers that it would be impossible to make up a quarter million for one transmission. This is one of the most difficult points for large transports. The institution receives from 20,000 to 30,000 eggs per day, and, taking into account the considerable loss in the incipient hatching, [*Anbrüten*,] it requires from twelve to fifteen days to collect a quarter of a million. With so great a difference in time of collecting, the eggs are, of course, not ready for transportation at the same time. It is true, at the very height of the season we obtain occasionally 80,000 to 100,000 eggs a day, and we have to arrange that such days be reserved for the intended large collection. These days mostly occur about the middle of December, and the eggs to be sent to America could not leave our place before the middle of January, since about five weeks are necessary for the incipient hatching. Besides, the day of sailing of the steamers has to be taken into consideration, and I believe there are only two trips per month during the winter-season. These are difficulties, to meet and to overcome which we have only the power in part; still I hope for good success. I consider it an affair of honor, and mention the many difficulties only to explain a possible mishap.

The sending of one-quarter million of eggs will require twenty-five single parcels, each consisting of two double boxes. Each parcel weighs about 10 pounds, and thus the whole 250 pounds, or 2½ hundred-weight. Believing it to be absolutely necessary that an expert should accompaniy the transport to Hamburg or Bremen, and direct the suitable packing there, the expenses will be quite considerable, scarcely less than 100 thalers per hundred-weight.

Since our institution furnishes the eggs gratis, and no funds are available to me for defraying expenses, I respectfully ask to have by the end of the year a sum of money of the above amount placed at my disposal, so that no delay may be caused by its want.

Accurate accounts will be rendered in time.

HAACK, *Director*.

Prof. S. F. Baird.

As a still larger number of eggs was considered desirable, at the suggestion of Mr. Hessel, I applied to Oberbürgermeister Schuster, of Freiburg, and ordered from him half a million eggs, which he agreed to furnish at the very reasonable price of two thalers per thousand, (their actual cost amounted to $1.67 currency per 1,000,) guaranteeing them to be taken from large healthy fish. These were also placed in charge of Mr. Hessel for shipment, who finally agreed to accompany the two sets of eggs to New York for the greater certainty of their reception in good condition.

As is well known, the best period for transporting salmon-eggs is when they are about half hatched, or when the eyes are visible through the envelope. They are then put up in damp moss in shallow boxes, and inclosed in other dampened receptacles. In this condition they may be kept out of water for a long time. Indeed, the eggs are not infrequently hatched out in the moss itself, if kept long enough, without being placed in water at all. Mr. Norris gives an instance of this kind in regard to some eggs which had been shipped from the Wilmot establishment at Ontario, a portion of them, that had been thrown aside with the damp moss having subsequently hatched, and this has since been confirmed by the experience of the commission.

Owing to the fact that the water at the Hüningen establishment was warmer than that at Freiburg, the eggs presented by the German gov-

ernment were developed first, those at Freiburg requiring some further time, so that it involved considerable effort to combine the two sets so as to prepare them for shipment to the United States at the same time.

Mr. Hessel, in accordance with the agreement, took charge of the eggs at Hüningen, as also those at Freiburg, and brought them to Bremen, where they were to be shipped on board one of the steamers of the North German Lloyd's. Unfortunately several circumstances concurred to render it doubtful to Mr. Hessel whether these eggs would come safely through. In the first place, the weather was exceptionally warm throughout Germany, no cold weather being experienced up to the middle of January, so that the eggs were developed in their shells much too fast for their welfare. It was impossible to retard these by the application of ice, as the stock in Bremen was very low, and supplies were only to be had at an enormous expense.

Again, the steamer upon which the eggs were first placed broke down, and was obliged to return to port. Mr. Hessel's packages were thus delayed and exposed to the continuous heat for another week. The consequence was that on his arrival in New York, to his great distress he found that the eggs had in large part been prematurely hatched, and the gases resulting from their putrefaction had destroyed many more of the eggs.

Application had been previously made to the Secretary of the Treasury for permission to land the packages containing the salmon-eggs without delay, and every facility was offered by the inspector of customs and other authorities. The boxes, sixty in number, occupying nearly 300 cubic feet of space, were transferred to the hatching-houses of Dr. Slack, near Bloomsbury, N. J., and the contents immediately assorted, but of the 750,000 eggs only four or five thousand were sound. These were successfully hatched out, and ultimately introduced into the Musconetcong, a tributary of the Delaware, and on which Bloomsbury is situated.

Much help was rendered in this experiment by the authorities of the North German Lloyd's, who gave up a special house on deck for the accommodation of the eggs, and assisted in various other ways, especially by advancing all the funds needed for the expenses in Germany and allowing the settlement of the account in New York. I had the assistance, also, in the reception and transfer of the eggs, of Dr. William M. Hudson, fish-commissioner of Connecticut, and of Mr. Seth Green, of New York, the whole party, with the exception of Dr. Hudson, proceeding to Bloomsbury with Dr. Slack, for the purpose of giving the eggs the best attention. I have no doubt that with a winter of average severity, which would not carry the eggs forward so rapidly as happened in this very exceptional instance, the transfer of salmon-eggs can be made from Europe without the slightest uncertainty as to their safe arrival. Perhaps a somewhat different method of packing would be required, and the inclosure of the eggs in smaller boxes would tend to promote their safety. In the ex-

treme probability that hereafter there may be obtained from American waters all the eggs that can be properly handled, I think it will be unnecessary to repeat the experiment.

The entire cost of the enterprise, including the purchase of the Freiburg eggs, the freights, the traveling-expenses and salary of Mr. Hessel, and every other outlay, amounted to $1,969.83, or to about $2.62½ per 1,000.

The value of this donation of eggs from the German government is not to be estimated by its worth in money, but is to be appreciated as an evidence of kind feeling on its part toward the United States, especially as there is a very great demand for salmon-eggs throughout Europe, and as the supply received from Hüningen is entirely insufficient to meet the calls from Germany alone.

12.—PROPAGATION OF THE CALIFORNIA SALMON IN 1872.

The propriety was strongly urged, at the Boston meeting, of sending some experienced fish-culturist to the west coast for the purpose of securing a large amount of spawn of the California salmon. This was the more proper, as the resolution originally introduced into the House by Mr. Roosevelt looked especially to the securing of a supply of eggs by means of hatching-houses on the Columbia River or elsewhere in the West; and I felt it incumbent to carry out the intention, although the law making the appropriation, as actually passed, contained no restriction.

Although considerable diversity of opinion exists with reference to the California salmon, most of those familiar with both species consider it nearly, if not quite, equal to the eastern salmon, and in some respects superior to it. At any rate, it possesses the advantages of existing in great abundance in our country, and of thriving in water, the temperature of which might not admit of the existence of the eastern species.

Accordingly, at the suggestion of the meeting, Mr. Livingston Stone was engaged to undertake this work, and proceeded to California as soon as he could arrange his affairs for the purpose. The experiment was of course uncertain, in the entire absence of any reliable information bearing upon the natural history of the species. It was not even known at what period they spawned, although Mr. Stone was assured by professed experts, on his arrival in California, that this occurs late in the month of September. This was thought the more probable, since the other salmon usually deposits its eggs in the end of October or the beginning of November. Mr. Stone left on the 1st of August, and arrived in due time in California, where, at my request, he reported to Mr. Throckmorton and the other fish-commissioners of the State, as well as to the president of the California Fish-Culturists' Association. By all of these gentlemen he was received with the utmost courtesy and kindness, and every assistance was rendered him. His instructions authorized him to select any point on the Sacramento or the Columbia River

that promised to answer best the purposes of his mission. Quartermaster-General Meigs had supplied him with letters of recommendation to the officers of his department in the West; but, to his regret, Mr. Stone found no military post sufficiently near to render him any particular assistance during the present season.

After much fruitless inquiry, Mr. Stone at last learned, chiefly through Mr. B. B. Redding, fish-commissioner of California, and through the chief engineer of the Central Pacific Railroad, that the Indians speared salmon on the McCloud River, a stream of the Sierra Nevada, emptying into Pitt River three hundred and twenty miles nearly due north of San Francisco. Proceeding to this station, in company with Mr. John G. Woodbury, of the Acclimatization Society, Mr. Stone immediately set to work in erecting the necessary hatching-establishment, although, on account of the distance from any settlement and the absence of special facilities, he found the undertaking both difficult and expensive. The efforts of Mr. Stone and his party were prosecuted unintermittingly, day and night, for a sufficient length of time to prove that the season had almost entirely passed, and that but few spawning fish remained. Many thousands of spawn were secured, however, and placed in hatching-troughs; but the extraordinary heat of the season, rising day after day to 110° and 112° in the shade, finally accomplished the destruction of the greater portion.

The surviving eggs collected by Mr. Stone (30,000 in number) were packed by him in moss and forwarded October 26 by express, addressed to his establishment at Charlestown, N. H., this designation being selected in the failure to reach him, of a letter directing their transmission to Dr. Slack, at Bloomsbury, N. J. On receiving a telegraphic dispatch announcing the shipment, I immediately telegraphed to Charlestown, directing the packages to be forwarded at once to Dr. Slack, and sent also a telegram to the office of Wells, Fargo & Co., at Albany, requesting that, if the eggs had not already passed that point, they might be intercepted there and returned at once to New Jersey. This dispatch came too late, as the eggs had passed when it was received; but the superintendent of Mr. Stone's establishment forthwith sent the eggs to New Jersey, with a skilled assistant to take charge of them and deliver them at their destination. Unfortunately, in consequence of the warmth, and through a miscalculation of the rapidity with which they accomplished their changes, the eggs were in large part hatched out on the journey, so that of the 30,000 originally shipped all but about 7,000 were hatched. The remainder were immediately picked out and placed in the hatching-house by Dr. Slack. The brood proved to be unusually hardy, very few dying, and all manifesting an extraordinary voracity for the food supplied to them.

By the advice of the various State commissioners and fish-culturists at a meeting in New York in October, it was concluded to place this stock of young fish in the Susquehanna; Mr. James Worrall, late commissioner

of fisheries for Pennsylvania, undertaking to do everything possible for their proper care. It had been the intention to transfer them from the hatching-house to the river as soon as the yolk-bag had become absorbed and the young fish were able to shift for themselves; but in consequence of the very cold weather which occurred during the winter, Dr. Slack was requested by Mr. Worrall to keep them until later in the season. They were therefore retained in the hatching-house and amply fed, from time to time, until the 3d of March, when they were taken to Harrisburgh and placed in the Susquehanna, being between five and six thousand in number. Only about one hundred perished on the journey, the rest being vigorous and in good condition. It is much to be hoped that some important result may follow this enterprise, especially if it be at all possible to add largely to the number in the course of the next few years. At the time of their introduction they were from 2 to 2½ inches long, showing the banded side very distinctly. They were much larger than the young of the *Salmo salar* at the same age, in this respect agreeing with the egg, which, in the Sacramento species, is fully twice the capacity of that of its congener.

The surprise of Mr. Stone at finding the extraordinarily high temperature in the Sacramento Valley, just referred to, was all the greater from the fact that he had been warned against being blockaded with snow during the same period. It is, therefore, probable that, as the season of 1872 was exceptionally warm, this obstacle to success will not continue on a subsequent occasion.

From Mr. Stone's experiences in 1872 he concluded that it will be necessary to commence operations as early as the 20th of July, and to have the breeding salmon caught and confined as early as the 20th of August. The hatching-water he proposes to take from the McCloud River, which is of so even a temperature that, notwithstanding the great heat, it does not rise above 54°. He would have used this water for hatching-purposes in 1871 but for fear of its rising by sudden freshets so as to destroy the establishment. He found, however, that the water altered only about two inches during his stay, and should operations be continued another season he proposes to employ it for the purpose, continuing operations at the same station. No better place is, indeed, to be had in California than the McCloud, as it is a very clear, cold, swift-running stream, full of salmon, and probably embraces the principal spawning-ground of that fish.

The spawning-beds lower down the river have been almost entirely destroyed by the washings of gravel and sand from the gold-diggings, which have exercised an unfavorable influence upon the supply.

According to Mr. Stone there are no white settlements on the river; but the Indians are numerous. The nearest highway is the Oregon stage-road, four miles from the river. Mr. Stone's party endeavored to enlist the Indians in their service, but were unable to communicate intelligibly with them, and were obliged to rely upon their own resources. As it was, their operations were somewhat delayed by the non-arrival of a

salmon-net which had been sent for. Mr. Stone had been assured that there would be no difficulty in securing aid from the Indians, which, however, he found to be entirely impossible.

We do not know enough of the natural history of the *Salmonidæ* of the West to decide as to the relationship of the Sacramento salmon to those of the waters farther north, especially of the Columbia and Frazer Rivers. Dr. Suckley and others are, however, of the opinion that the same species extends from California to Alaska; but that, while there are additional species in the northern waters, only one inhabits the Sacramento. Its flesh is much more highly colored than that of the eastern salmon, being almost of a dark-red, and its flavor is said to be fully equal, if not superior; although about this there is a great diversity of opinion. In its proportions it differs, being shorter and thicker, so that one of them weighs considerably more than a fish of the same length taken from the East. Further considerations as to its value and adaptability to eastern waters will be found farther on.

13.—PROPAGATION OF WHITE-FISH IN 1872.

The white-fish breeding was begun in the fall of 1872. Over half a million of eggs were placed in the troughs of Mr. N. W. Clark, an experienced breeder of Clarkston, Mich. These were obtained at Ecorse, on the Detroit River, through the liberality of Mr. George Clark of that place, with but little expense. On the 20th of January, 1873, about 200,000 eggs, partially developed, were shipped to the fish-commissioners of California, but did not arrive in good condition, having either smothered from the thick bed of sawdust in which the case containing them was placed or been killed by the excessive cold. A second lot of one-half the number was shipped to the same destination with excellent success. These were placed by the commissioners in a hatching-house provided for their reception, and the young fish soon after were put into the waters of Clear Lake.

The white-fish is of great value, because of the excellent flavor of the flesh, both fresh and salted, its fecundity, and the fact that it feeds on crustacea and other invertebrate forms. It is adapted to the larger and cooler lakes of the interior, and like the rest of the salmonoids is easily propagated artificially.

14.—PROPAGATION OF SHAD IN 1873.

As shown in the first part of the present report, the shad-hatching season was so far advanced at the time of the passage of the act making an appropriation for the service in 1872 that little could be done. The appropriation itself was not available until the 1st of July; and as the appropriation bill containing the item was passed just before the adjournment of Congress, on the 10th of June, it was necessary to make sure that the item was included therein before taking any measures that might involve any expense. An account of the work actually accomplished in 1872 is given on p. xvi.

Owing to the earlier date at which the necessary appropriations were made by Congress for the propagation of food-fishes, especially of the shad, in 1873, I was enabled to take timely steps looking toward this great interest, the plan adopted being to hatch out the fish in the rivers of the Atlantic coast, and to transfer a suitable portion of them to western waters, beginning in the south, and conducting operations farther and farther toward the north as the season advanced.

Entirely ignorant of the best points where this work could be carried on, I dispatched Mr. Yarrow on a tour of reconnaissance, and was very much surprised [illegible] from his report (page 396) that, in consequence of the scarcity of fish, it would be extremely difficult to get enough to experiment upon, farther south than the Neuse. This conclusion was found to be correct, by the subsequent experience of the parties entering upon the work.

Desirous of utilizing the practical experience in shad-culture of Mr. Seth Green, I made arrangements with him to devote his whole attention to the business of hatching shad in behalf of the United States, or at least until it became necessary for him to commence operations on the Hudson River for the State of New York. He accordingly reported himself in Washington on the 17th of April, with his trained assistants, Mr. H. M. Welsher, Mr. Jonathan Mason, Mr. M. G. Holton, and Mr. Chester K. Green. As agreed upon, he proceeded first to the Savannah River at Augusta, Ga., but, to his disappointment and my own, was unable, as already explained, to find enough spawning shad to make the experiment worth the cost.

New Berne on the Neuse, and Weldon on the Roanoke were next fixed upon as stations. Unfortunately the unprecedented rise in the rivers prevented anything like the success we had hoped for; the streams being many feet above high-water mark, rendering it impossible either to catch the shad, or to hatch out the spawn properly had it been possible to procure it. The most important result of the experiment at Weldon was the discovery by Mr. Holton that the striped bass or rock-fish could be propagated in the same manner as the shad. Several spawning fish were stripped of their eggs, which were fertilized and placed in the shad-boxes. They were found to develop in rather less time than the shad, and to be capable of quite a similar treatment generally.

As this fish has diminished equally with the shad, and is much more valuable on account of its greatly superior size, we have here the warrant as to further operations, which it is proposed to carry into effect hereafter.

The operations at Weldon were under the charge of Mr. M. G. Holton and Mr. C. K. Green; and on the 17th of May a camp was established on the Potomac River by Messrs. Mason and Welsher, and the first work of any magnitude commenced. About one hundred hatching-boxes were prepared according to Mr. Green's pattern, and anchored above the western end of the Long Bridge opposite Washington, and advantage

was taken of an adjacent fishery belonging to Messrs. Knight & Gibson to secure the spawning fish. Here about 1,400,000 young shad were placed in the river, increasing the supply to that amount. It was now for the first time possible to make a transfer of fish to the West; and having placed Mr. Milner, an assistant of the commission, in charge of this branch of the work, he succeeded, with the assistance of Mr. Welsher, in introducing about 70,000 fry into the headwaters of the Kanawha River on the 6th and 9th days of June. A supply was also furnished to Mr. N. W. Clark for the Michigan commissioners.

The season having closed at this point in consequence of the heat of the water, and the fact that the spawn taken from the fish invariably failed to develop, two new stations were established; one under Mr. Welsher, at Marietta, in Pennsylvania, and the other under Mr. Holton and C. K. Green, at Bull's Island Ferry, on the Delaware. The business arrangements of this branch of the work were placed in charge of Dr. J. H. Slack, who, as fish commissioner of New Jersey, had certain privileges in regard to the capture of the shad, which were important to the success of the enterprise. The fish hatched at this point were principally placed in the Delaware River, although 15,000 were transferred by Dr. Slack to Jack's Run, at Greensburgh, for the purpose of stocking the Monongahela.

About the time of the starting the camp at Marietta, the Pennsylvania commissioners began another at Newport on the Juniata, where a considerable number of fish were hatched and placed in the river.

The operations on the Delaware were closed in July, mainly in consequence of certain obstructions introduced by the canal company above the hatching-camp, and the regular parties proceeded to the camp on the Hudson, at Castleton, where the New York commissioners have a station, and where a considerable supply of spawn was to be expected. Here the hatching was prosecuted entirely at the expense of the State of New York; her fish commissioners, however, very kindly giving the United States such spawn as was required for its purposes. Mr. Milner assisted by Mr. Mason was actively engaged for several weeks in transferring young shad from Castleton to various points in the West, becoming so well skilled as to involve a very slight mortality.

At the same time Mr. Livingston Stone, in behalf of the United States Fish Commission, received 80,000 fish from the establishment of the New York commissioners, none of which reached their destination; the attendant who carried them through to Chicago, where they were to meet the aquarium-car, failing to success in keep them alive during their journey.

The attempt to transfer valuable food-fishes from the Atlantic slope to the Pacific slope in the so-called aquarium-car, as well as the unfortunate accident by which the car was precipitated from a trestle-work into the Elkhorn River of Nebraska not far from Omaha, have become widely known through the newspapers. The enterprise was a joint affair

between the United States and the State of California, through her commissioners, Messrs. Throckmorton, Redding, and Farwell.

The car, in charge of Livingston Stone, assistant United States commissioner, was ingeniously and very completely fitted up in every detail of necessity and convenience required for the successful transfer of fishes, obsters, and oysters. It contained in all nearly 300,000 fishes, representing the following species: The tautog, (*Tautoga onitis;*) the black bass, (*Micropterus salmoides;*) the rock-fish or striped bass, (*Roccus lineatus;*) the perch, (*Perca flavescens;*) the wall-eyed pike, (*Stizostedion americana;*) the brook-trout, (*Salmo fontinalis;*) the bull-head, (*Amiurus atrarius;*) the cat-fish, (*Ictelurus cœrulescens;*) the eel, (*Anguilla bostoniensis;*) besides minnows, (*Cyprinidæ,*) to serve as food for the larger individuals *en route.* One hundred and seventy lobsters and a barrel of seed-oysters were also in the car.

To accommodate these, one very large tank, and ten smaller ones, besides hogsheads, barrels, and tin cans, were required.

A large amount of ice, and reserves of sea and fresh water, were provided, as well as supplies of food and apparatus for aerating water and regulating temperature. Sleeping and feeding accommodations for attendants were arranged within the car.

By the accident, the car was thrown into the Elkhorn River, and the fishes had an opportunity of escape from the tanks. It is not likely that the lobsters, oysters, or the tautogs were able to sustain life in the fresh waters of the river for any great length of time. The rock-fish and the shad are anadromous fishes, spending a portion of each year in fresh waters, and both have proved their ability to sustain life in fresh waters through several years. The other species are fresh-water fishes, and some of them will be valuable acquisitions to the system of waters where fate has consigned them.

A full account of this expedition and of the accident which interrupted it so suddenly, and from which Mr. Stone and his companions barely escaped with their lives, will be found in the body of the report.

Mr. Stone, having lost the first installment of shad, was directed to return to Albany for the purpose of taking an additional supply; and he again started on the 25th of June, with about 40,000 fish, accompanied as far as Omaha by Mr. Welsher. I am happy to state that they experienced scarcely any mortality on the way, and after placing 5,000 fish in the Jordan River, a tributary of the Great Salt Lake, on the 30th of June, he deposited 35,000 in the Sacramento on July 2, in the presence of the California commissioners, and to their very great satisfaction. This number of young fish in the Sacramento River, to be increased, I hope, hereafter, will very probably result in supplying that stream with this useful food-fish, and will furnish a point of departure from which to stock the Columbia and other more northern rivers, as contemplated by act of Congress. Experience has shown that it will be impossible to take young shad from the east over a greater distance than the Pacific

Railroad will carry them; and until the northern line, or the coast-line from California to Oregon, is completed, it will hardly be worth while to spend our efforts in that direction.

In order to have a still greater supply of young shad for the purposes of the commission, an arrangement was made with the Connecticut commissioners to enlarge their operations at Hadley Falls, the increased expense being borne out of the appropriation made by the United States. This was accordingly done, and Mr. Milner and Mr. Mason were enabled, after the season had closed farther south, to obtain all the young shad they could attend to during the remainder of the season.

A deposit in the Mattawamkeag, a tributary of the Penobscot, was made at the urgent request of the commissioners of Maine.

Mr. Milner and Mr. Mason next proceeded to Topsham, Me., on the Androscoggin, with a view of ascertaining whether ripe eggs could be obtained in sufficient number for shad-hatching purposes. They found, however, that, owing to the lateness of the season and the scarcity of the fish themselves, nothing could be done; and it is thought not improbable that the restoration of shad to the rivers of Maine will be done most easily by transferring the spawn from the Connecticut, or from the Merrimack, should the commissioners of Massachusetts exhibit the same liberality that has been shown by those of Connecticut. Returning from Maine, they proceeded again to the Connecticut and the Hudson, continuing their labors in the way of transferring of young fish. Their work finally closed on the 24th day of July.

An accompanying table gives the statistics of the work actually accomplished in transferring shad to western waters. The aggregate of nearly a million is certainly likely to produce a marked effect; and if similar efforts are made in successive years, which I trust will be the case, there is every reason to expect the accomplishment of the object in view. The information in this and other tables, as to the entire number of shad and salmon hatched in the United States to date will not be without interest.

The accompanying very valuable report by Mr. Milner, (page 419,) gives the details of his operations, and embraces numerous very valuable suggestions in regard to the transportation and treatment of shad, which will serve an important purpose in future operations.

I append reports from Mr. Green, of his labors south of Washington, (p. 406;) from Dr. Slack, upon work on the Delaware, (p. 409;) and from Mr. Stone, (p. 413,) upon his transfers to the Jordan and Sacramento.

During the present season, as in the past, I have great pleasure in acknowledging the help rendered by many persons, not only by the State commissioners, (especially those of New York and Connecticut,) in supplying young fish from States where the United States had no hatching-house, but also by the part of officers of railroad and express companies. Most of these are mentioned hereafter.

It had been contemplated to carry on hatching-operations on the Rappahannock River, where the shad were believed to be very abun-

dant, and where, it was thought, a large number of eggs might be obtained and transferred to the West. The most suitable point on this river was some distance below Fredericksburgh; and at Mr. Green's suggestion I applied to the governor of Virginia, asking the loan of one of the State fishing-steamers for my aid, which was promptly acceded to, and I was informed that the steamer Tredegar, in command of Capt. Orris A. Browne, would be at my service at any time after the 1st of May. It, however, was found impossible to occupy more than two stations at a time, owing to the small force at my command, and when the experiment at Weldon was given up, and Messrs. Welsher and Green proceeded to the Rappahannock, they found the season had passed, and that no success was possible. Another year it may be expedient to commence operations on this river, especially in view of the fact that it affords a convenient point from which to transfer the young fish to West Virginia, Kentucky, and Tennessee.

C—MULTIPLICATION OF FISH IN GENERAL.

15.—GENERAL HISTORY OF FISH-CULTURE.

Having presented in the introductory portion of the present report a general account of the measures taken to carry out the intention of Congress in establishing the Commission of Fish and Fisheries, I now proceed to give in more detail a statement of what has been done generally in regard to the multiplication of the species of fish considered of most importance, and the various interests connected with the fisheries, to which a brief sketch of the theory and practice of so-called fish-culture may not be an unacceptable preliminary.*

The subject of securing from the fresh waters and the sea a larger supply of fish than they would spontaneously afford has attracted the attention of various nations from a very remote period; one of the simplest methods consisting in the collection of fish into natural or artificial ponds or reservoirs, and by allowing them to prey upon each other, or else by supplying food to them artificially. This was in vogue among the Romans especially, and it is asserted that not unfrequently the food thus supplied consisted of the flesh of slaves, which it was claimed imparted to the fish a delicate flavor, especially to the lampreys and other favorite species. This method of treating fish is, however, scarcely to be regarded as a branch of fish-culture in its restricted sense.

According to Soubeiran, in a recent and very complete summary of the history of fish-culture†, the first essays made in this direction in

*A fuller account of this will be found in the History of Fish-Culture, page 465.

†La pisciculture et la pêche en Chine par P. Dabry de Thiersant, consul de France, membre honoraire de la Société d'acclimatation; ouvrage accompagné de 51 planches, représentant les principaux instruments de pisciculture et engins de pêche employés par les Chinois et quelques nouvelles espèces de poissons recueillies en Chine par P. D. Thiersant, précédé d'un introduction sur la pisciculture chez les divers peuples par le Dr. J. L. Soubeiran, professeur agrégé à l'École de pharmacie de Paris, secrétaire de la Société d'acclimatation.

Europe were by Dom Pinchon, in the fifteenth century, at the abbey of Reôme, near Montbard, in France, and in a manuscript dated A. D. 1420, belonging to the Baron de Montgaudry, describing his process, it is said that it is necessary to have long wooden boxes, with solid bottoms, but with wicker-work at the ends, open above, and covered with a willow grating. At the bottom of the box is to be placed a bed of fine sand, and a slight groove is to be made in the sand, in which to deposit the eggs, which have previously been fertilized. The trout is to be kept in a gentle current of water; and as soon as the discharge of ova has taken place, (the period of which is carefully watched for,) and these are fertilized by the milt of the male, the eggs are to be removed to the boxes referred to, and allowed to remain until hatched out.

About the middle of the eighteenth century the subject of fish-culture was again brought into notice by the experiments of Lieutenant Jacobi, of Hoenhausen. An account of his labors forwarded to Count de Goldstein was translated into Latin by that gentleman, and later into French by Duhamel du Monceau. The method adopted by Jacobi was that of modern times, namely, the squeezing of the ripe eggs from the body of the female into a dish partly filled with water, discharging upon this the milt of the male, stirring them well together, and afterward placing them in the boxes for hatching.

According to Adanson, as early as 1772 some form of artificial fecundation, of trout especially, was made use of on the borders of the Weser, in Switzerland, in the Palatinate of the Rhine, and in many of the more elevated regions of Germany.

The methods of Jacobi, and his results, seemed for many years to have passed into oblivion, although various experiments were made for some time after, in one country or another, looking more particularly toward the increase of the salmon and the trout. No material progress seems to have been made, however, until the time of Joseph Rémy, a simple fisherman of Bresse, a village in the Vosges, who by his own ingenuity discovered the general theory of artificial fecundation, and again carried into effect, but much more efficiently, the methods of Jacobi. To him is due the fuller appreciation of the importance of artificial fecundation, and of protecting the eggs and young fish during the period of greatest danger. It is well known that there is no more attractive food for aquatic animals than the roe of fish, even the very parents of the eggs in many cases devouring them greedily. It is not too much to claim that, as a general rule, 60 per cent. of all eggs are devoured before the young are hatched; and it is also certain that of the latter, three-fourths are probably eaten while in their helpless condition, with the yolk-bag attached, and before they are able to feed themselves and to take the natural precautions for their safety.

Again, a serious loss is experienced in the uncertainty of natural fecundation, many of the eggs failing to receive the spermatic fluid, and of course remaining inert. The estimate has repeatedly been made that

if 5 per cent. of the number of eggs laid under natural conditions by the parent become young fish, able to feed for themselves, it is rather more than a usual occurrence. Of course, subsequent to this stage they are exposed to numerous dangers before the perils of immaturity are passed. On the other hand, if more than 10 per cent. or even 5 per cent. of those artificially hatched fail to reach the same period of existence, especially in the case of the eggs of the salmon and trout, which are large, and are usually more carefully manipulated, it may be considered as unsuccessful management. This fact, which is one of the most important features in the success of artificial hatching of fishes, was appreciated by Rémy, and provided for in his various methods. These he practiced with only one associate, named Gehin, for several years; but it was not until 1849 that they became known to the scientific world through Haxo and Professor de Quatrefages. The subject was taken up by the French government, and the final result was the erection, at Hüningen on the Rhine, of a great French national establishment for the artificial cultivation of fish, and their distribution to the adjacent waters, under the direction of Professor Coste, of the College of France.

This took place in 1851, and the work was carried on by the French with varying success until the capture of Alsace and Lorraine by the Germans. The Hüningen station, being now within the German limits, is still maintained as a piscicultural establishment, and is under the immediate charge of Dr. Haack, one of the most eminent pisciculturists in Europe. The *Salmonidæ* receive chief attention at this establishment, although some species of other families are cultivated. It was from this place that the salmon-eggs already referred to as presented by the German government to the United States were supplied.

At the present day there are few countries of Europe where fish-culture in some form is not prosecuted. There are numerous establishments in France, Germany, Great Britain, Norway, Sweden, Russia, Denmark, Holland, Belgium, Italy, Spain, &c., while even in India, Java, and Australia more or less attention is given to the subject.

The claim has been raised in behalf of China as having earliest practiced pisciculture. But if by this we mean the artificial fecundation of fishes, and raising them in limited spaces, the assertion cannot be sustained. It is very true that great ingenuity is expended in China in securing the fertilized eggs of fishes after they have been already deposited by them, and in rearing the young, as well as in stocking waters with the most approved varieties. In this respect, indeed, they may be said to have prosecuted the art of aquiculture as well as of agriculture from a period far antedating the practice of the same by any other nation. They, however, as far as the eggs of the fishes were concerned, confined their efforts to finding the localities where these had already been laid, or else to straining them out of the water by means of fine nets, mats, or gratings, and then they either hatched them out on the spot or carried them to great distances throughout the empire. It is,

however, for the United States that we may claim the fullest development of the art of pisciculture, both as to the perfection of its methods and the extent of its operations.

On the authority of the Southern Cultivator, the Rev. Dr. John Bachman, of Charleston, S. C., as early as 1804, at the age of fourteen, impregnated and hatched the eggs of trout and other fishes. This has been questioned by some; but Dr. Slack, in his work on trout-culture, well remarks that Dr. Bachman's reputation as a Christian and a naturalist is too well established to permit us to doubt his word. It is not pretended, indeed, that the idea was original with him, but he probably found in the work of Duhamel du Monceau the account of the methods of Jacobi and imitated them.

In 1853 Dr. Theodatus Garlick and Professor Ackley established a fish-farm near Cleveland, Ohio; the result of their experiences being published in Dr. Garlick's work, entitled "A Treatise on the Artificial Propagation of Certain Kinds of Fish; Cleveland, Ohio, 1857."

In 1859, Mr. Stephen H. Ainsworth, of West Bloomfield, N. Y., began his experiments, and has continued them up to the present time. Since then, numerous establishments have been started, more particularly devoted to the culture of the brook-trout, meriting and meeting a greater or less degree of practical and pecuniary success.*

I am indebted to Mr. Stone for a list, brought up to 1872, of persons at that time known by him to have been engaged in the practical work of fish-culture, or more or less interested in its success. Although necessarily incomplete, I have given it in the appendix as the basis of a fuller enumeration hereafter. Among the more prominent names in this connection we may mention the world-renowned Seth Green; Dr. J. H. Slack; Livingston Stone; William Clift; S. H. Ainsworth; A. S. Collins; N. W. Clark, &c.

16.—ACTION OF STATE AND NATIONAL GOVERNMENT.

The recent establishment of the American Fish-Culturists' Association, a society designed to bring together those interested in the subject, promises to be of great benefit in advancing a correct knowledge of the best theory and practice of the science of fish-culture. It is to this body, under the presidency of Mr. George Shepard Page, that we owe the first movements which resulted in the recognition, by Congress, of the national importance of fish-culture, and in the appropriations for the multiplication of useful food-fishes in the national waters.

As already stated, (page xvi,) it was in 1872 that the subject was presented to Congress and favorably acted upon; the result being an appropriation of $15,000 "for the introduction of shad into the waters of the Pacific States, the Gulf States, and of the Mississippi Valley, and

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* Fuller details in regard to American fish-culture are given farther on in the article by Mr. Milner, page 523.

of salmon, white-fish, and other useful food-fishes, into the waters of the United States, to which they are best adapted," for the fiscal year of 1872–'73, with a supplementary appropriation of $10,000 for the same year, having special reference to the propagation of shad. A further appropriation of $17,500 was subsequently made for the same object during the fiscal year of 1873–'74. This action on the part of the United States was the natural culmination of what had already been done by many of the States, accelerated by the action of the American Fish Culturists' Association. (See page xvi.)

At an early period the subject of protecting the fishes, if not, indeed, of their actual multiplication, was brought before the legislatures of certain States, and various laws were enacted, and commissioners appointed to attend to their enforcement. In many instances their efforts were restricted to preventing injurious, unseasonable, and excessive fishing; but in others they were also instructed to take such measures as lay in their power to increase the supply. This has already been done to a greater or less extent in the States of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Virginia, Alabama, Ohio, Michigan, Utah, and California, as well as in the Dominion of Canada; and as year by year the number of States taking action in this matter and extending operations therein is increasing, there is little doubt that before long nearly all the members of the Union will have fish commissioners duly appointed and qualified to act in reference to this important branch of our internal resources.

A list of the States which to the present time have appointed commissioners, with the names of the officers themselves, will be found in the accompanying appendix, and also a bibliography of the reports published by them. While, however, the action of the commissioners of the several States has reference to restricted localities, and to introducing new varieties, or increasing the supply in ponds, small lakes, and streams, they have not been disinterested enough to take charge of waters which constitute State boundaries, or where the benefits are likely to be shared, if not entirely reaped, by citizens of other States. For this reason some of the more important rivers, and the entire system of the great lakes, the best subjects for the experiment, have been entirely neglected; and as these constitute the common waters of the United States, it was thought desirable for Congress to take charge of them, and to do whatever was possible within a moderate cost to increase the supply of food to be derived from them. Thus, it was impossible to secure State action, in stocking the Mississippi with the anadromous fishes, or those that run up from the ocean to the headwaters of the streams to spawn, the shad for instance, which it is believed can be made as abundant in that river and its tributaries as it now is in any other waters. Wherever the young fish may be introduced, after reaching a certain size they will descend to the Gulf of Mexico, returning in the course of three or four years, if permitted, to the spot

from which they originally started. Supposing a locality in Ohio to have been their first abode, there will be nothing to prevent the citizens of all the States intervening between that place and the Gulf of Mexico from arresting the upward returning run, and capturing a portion, if not the entire body of the fish, so that little or no benefit would inure to the parties through whose instrumentality this result was rendered possible.

As far as the United States is concerned, however, it is a matter of no consequence who take the fish, since the great object is to increase the supply of food to the nation at large, and every capture, whether in Ohio or Louisiana, will tend to accomplish the same general result.

After any species of fish has become permanently established in a given body of water, their continuance therein will depend in great measure upon the enactment of suitable laws, securing their access to suitable spawning-grounds, and protecting them during the critical period of their existence, from capture or unnecessary destruction. Otherwise the methods of artificial propagation must be resorted to indefinitely. The various measures required for the protection of fish will be referred to hereafter.

17.—COMPARATIVE VALUE OF ANADROMOUS AND OTHER FISHES.

In reference to the fresh-water fishes most worthy to attract the attention of the General Government or of the States, the distinction between resident species and those that are anadromous, or which spend a part only of their life in the fresh waters and the remainder in the ocean, must be clearly borne in mind. The species which belong exclusively to fresh water, such as the brook-trout, the lake-trout, the land-locked salmon, the white-fish, the black bass,* &c., are well worthy of attention, and by judicious treatment can be introduced into new waters, or their numbers greatly increased in any particular locality. But, after all, there is a direct relationship between the number of any kind of fish of a given weight and the amount of water needed to furnish a supply sufficient to add definitely to that weight of food; and when the limit has been reached, we cannot, without feeding artificially, advance upon the proportion. Where the waters are pure and constantly renewed, and a suitable supply of healthful food is furnished regularly, large numbers of fish may be kept and cultivated, where not one in ten thousand would find an ample supply of natural food; but, as a general rule, the expense of feeding is such as to render the sale at comparatively high prices necessary for a satisfactory result.

It must be remembered, too, that however rapidly certain fish, especially the black bass, multiply in new waters, there is a limitation to their increase, as shown by the experience of the Potomac River.

* All these species are able to live for a time in salt-water, and, indeed, if no obstacle intervene, may run down to the sea for a time; but by far the greater number belong to the interior waters of the country, and have no opportunity for such experiences.

This fish was introduced into this stream in 1854 by Mr. William Shriver, of Wheeling;* several mature fish having been transported

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* As an important contribution to the history of the black bass and of the measures taken to introduce it into new waters I reproduce a letter by John Eoff from the report of the Smithsonian Institution for 1854:

"On my return from a small hunting expedition to the headwaters of Sand Creek, Jackson County, Virginia, I found your kind letter of November 26, 1854; and, in order to comply best with your wishes and views therein expressed, I will give you such a description of one particular species of fish, (which I consider the most valuable, on account of their quality as a pan-fish and their quantity,) in our western streams, viz, the bass, (called by the early settlers in the western country yellow or black perch.) They are a remarkably active and voracious fish, with a large and hard mouth, and vary in size, according to their age, from three-quarters of a pound to three pounds, and occasionally have been caught to weigh as high as six pounds or seven pounds. Their food, when small, appears to be all kinds of insects, (flies, worms, &c.;) when larger, though not entirely leaving off their earlier habits, their principal food is the smaller fish of other kinds. In the winter-season they retire to deep and still water, and apparently hide under rocks, logs, &c., and remain there until the first of April, when they come out and begin to ascend the streams, apparently to find a convenient place for spawning, which commences about the 15th of May, varying some little according to the warmth of the season, &c. When that event is about taking place, they appear to separate into pairs, male and female, and hunt out some retired place, or nook, where the water is about eighteen inches deep, and still, but adjoining deeper water, to which they can escape if alarmed; they there commence making their nests, that is, washing all the mud, &c., off the bottom, so as to leave it perfectly clean, in a circular form, the diameter of the circle (or nest) being about twice the length of the fish; after which the female begins depositing her eggs, which appear to become glued to the bottom, or small stones, in rows, after the deposit has taken place. She remains night and day, either on her nest, or swimming round about it, apparently guarding the eggs, and driving every other smaller fish away. This watching or guarding continues until the eggs are what is called *hatched*, which occurs in from eight to ten days, according to the temperature of the water. The young fish at first remain near the bottom, and appear like a gauze vail floating. In two or three days they gradually rise and spread, the old one leaves them, they separate, and each one shifts for itself, *i. e.*, hides under leaves, small sticks, and stones.

"I, as yet, have had no positive means of determining the precise time for a young bass to arrive at *maturity*, but suppose it to be three years, from the following facts: In the spring of the year (April) you may find large numbers of young bass about two or two and a half inches in length, rather in company with other minnows; in the following autumn and fall of the year you will find very few of that size, but congregating together, and alone, you will find a number from three to four inches in length; while during the same fall you may catch young bass of about eight inches long, with the formation of the young egg within them, preparatory for spawning the following spring. In the spawning-season you will find a large number of nests of small bass, the bass being ten or eleven inches long, which I have always concluded were three years old. Hence, from the above facts, you will perceive that the bass of our western country are valuable, and, at the same time, can be easier transferred, and in greater quantities, from one stream to another, than almost any other fish. All that is necessary to supply a pond with any quantity would be to examine their nests at the time they are spawning, and to pick up the small gravel out of their nests, with the eggs attached thereto, and put them in a bucket of water, and place them in your pond, in such a position that smaller fish could not devour the eggs; and in a short time they would hatch, and the young ones would help themselves. Or, to secure a larger quantity in a short time, wait until the young are hatched, and are in innumerable quanti-

in the water-tank of a locomotive from the Ohio River, at Wheeling, to Cumberland on the Potomac. Not many years after, the young fish began to distribute themselves in numbers, and in time the entire river became thoroughly stocked with the new game. Starting at the head-waters of the river, the bass found immense numbers of *Cyprinidæ*, such as chubs, minnows, suckers, &c., as also of crawfish, insect-larvæ, and the like, which had been previously, for the greater part, undisturbed, except, perhaps, by the pickerel, and, having an ample supply of food, in accordance with the theory of natural selection, they multiplied to a prodigious extent. Year by year they extended their limits toward the mouth of the Potomac, until at the present time they are found in great abundance near Washington, and form a very attractive object of sport.

I am, however, informed by residents on the Upper Potomac and its tributaries that the bass are becoming scarce, and that their numbers are much less than a few years ago, while, as a concomitant, the immense schools of smaller fry, formerly so abundant, have disappeared, a minnow in some localities being a rare sight. This is a very natural consequence, and must produce its result. In the increasing scarcity of herbivorous fish, the bass wlll be driven to feed more and more upon each other, and after a time a certain average will be established, perhaps the same as that existing in the waters of the Mississippi Valley and elsewhere, where, although indigenous, they are in proportion fewer than in the Potomac River.

An entirely different condition of things prevails with the anadromous fish, among which we may enumerate as best known the shad, the alewife, or the fresh-water herring, the salmon, the smelt, and probably the striped bass. These fish spend the greater part of their existence

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ties suspended over the nest; then, with a piece of gauze net, dip them up and empty them into a vessel containing as much pure water as will sustain them until you can convey them to your pond; and then, as I before observed, they can support themselves, while young, on insects, &c. Or, early in April or May, if you are fond of angling, you can go to a stream in which they are plenty, and, in catching fifteen or twenty, will almost always get nearly one-half the number smaller ones. Put these into your pond unhurt; and, as they have not spawned that season, they will soon stock the water. Then all that remains to be done is to supply your pond with other small fish, minnows, &c., for food for the large bass, and they will increase in quantity just in proportion to their supply of food. Hence I am satisfied that if a farmer would convert one acre of his land into a pond, well supplied with fresh water, that acre would raise and support more fish yearly (the value of which would be more) than any other two acres cultivated in any other manner—the expense of cultivating deducted from each.

"Mr. William Shriver, a gentleman of this place, and son of the late David Shriver, esq., of Cumberland, Md., thinking the Potomac River admirably suited to the cultivation of the bass, has commenced the laudable undertaking of stocking that river with them; he has already taken, this last season, some twenty or more in a live box, in the water-tank on the locomotive, and placed them in the canal-basin at Cumberland, where we are in hopes they will expand and do well, and be a nucleus from which the stock will soon spread."

in, and derive their chief growth from, the sea. At certain seasons of the year, when fat and plump, they enter the rivers and proceed usually as far as the obstructions will permit, or until they find their proper spawning-ground; here the eggs are discharged, fertilized, and hatched. The adults either return immediately to the ocean or after a certain interval. The young fish spend a certain period in the fresh waters, feeding, it is true, but on minute organisms, which are always procurable in abundance.

Shad and herring enter the rivers and spawn in the spring, and the young return in the autumn. The eastern salmon enter the rivers in spring, and spawn in the autumn, the eggs not hatching until late in the winter. The young remain for one and some of them even for two years, and then go down to the sea. After a certain interval these fish return to their birth-place, the shad, at the age of three or four years, weighing from three to five pounds; the salmon after the same interval, weighing from nine to twelve pounds; this immensely rapid growth having taken place in the ocean, and without requiring anything in the way of human intervention. For this reason it is that the efforts necessary to the multiplication of anadromous fish may be limited to securing a proper passage of the adults to and from their proper spawning-grounds, or, in addition, to the securing of their eggs in numbers, and placing the young when hatched, and after a suitable interval, in the water where they are to pass the period of their infancy. Nothing, therefore, is asked of the waters but the right of way, the adults rarely taking food of any kind while in the rivers. Their sustenance during this period is derived from the surplus of fat in their own bodies, and the exhaustion produced by this period of abstinence, especially with its accompaniment of the development of the eggs and their fertilization, being made up by the voracity of their feeding on returning to the ocean.

The species just mentioned all live in the ocean and run up into fresh water to spawn; the list being capable of considerable addition. Other fishes, again, live in large bodies of fresh water, as lakes, and run into tributary streams or outlets for a similar purpose, and are thus anadromous likewise. The *Coregonus* or white-fish, are almost universally anadromous; also the land-locked salmon, the oquassa-trout, or blue-back, the fresh-water smelt, &c.

In this connection it may be interesting to refer for a moment to the difference in habits between the common eel and the species just referred to. This, like the others, is an anadromous fish, or better, perhaps, *catadromous*, the order of its movements being reversed. The eggs of eels, for the most part, are laid in the sea, and the young, after a short interval, enter the mouths of rivers and streams in early summer and pass up as far as an open passage will permit. The adventurous visitor to the Cave of the Winds, under the water-sheet of Niagara Falls, is struck as much by the immense number of young eels swarming against

the rocks and attempting to climb over their surface as by any other feature, the numbers to be seen being simply incalculable.

After reaching a suitable place of abode, in fresh water, the eels remain, as is supposed, for at least three years, growing to a considerable size. After becoming sufficiently mature, their instinct, probably that of reproduction, carries them seaward again during the autumn; and it is at this time that various forms of fish-dams and fish-weirs are called into requisition. The simplest kind consists of two lines of stone wall, forming the sides of a rude dam, made so as to converge and bring the angle down stream, through which the passing water falls into a sort of basket. This consists of a frame with lattice-work at the bottom, so arranged that, while the water passes through, the fish are forced up over the slats, arranged so as to form a series of slides, and fall into a receptacle beyond, where they are taken sometimes by wagon-loads. The most productive result of this mode of fishing consists of eels intercepted in their seaward movement, although other fish are often taken. It is very destructive to young shad and is very properly interdicted by the laws of Pennsylvania and New Jersey, in their shad-rivers.

The laying of the eggs, it is supposed, takes place in the autumn, or winter, and the young begin to move up in the spring, or early summer.

In further reference to the history of the eel, we may state that its precise mode of copulation and of reproduction was entirely unknown until recently, but that at the present time the view is maintained by very high authority, principally that of Italian physiologists, that the eel is strictly a hermaphrodite; that is to say, that both the male and female organs are found in the same animal. These are said to be developed to the proper degree in winter, and the eggs discharged from the ovary are fertilized by the seminal fluid from the testicles, and leave the body in a condition for further development.

18.—DIFFERENT METHODS OF MULTIPLYING FISH.

We have already indicated in the previous remarks some of the principal methods devised for increasing the number of fish in a given locality, but it may be well to refer again to this in a more systematic manner. Capturing fish in one locality, and transferring them to another, simply for the sake of greater convenience in securing them when wanted, does not come under this head. The fish-ponds of the ancient Romans, and the floating boxes or cars in which living fish are kept by fish-dealers, belong essentially to the same category. As far as the actual multiplication of fish is concerned, we have to deal especially with four principal methods.

The first, and simplest, consists in transferring fish of both sexes, whether still young and requiring further growth, or fully mature, and especially at about the period of their spawning, from one locality to another, where they can make themselves at home, and in due course of time increase and multiply.

This method has been more especially practiced in the United States in the case of black bass, pickerel, * pike-perch, yellow perch, alewife or fresh-water herring, the brook-trout, &c., and to some extent, indeed, the white fish, or *Coregonus albus* † and, indeed, is almost the only method by which it is possible satisfactorily to accomplish the desired object; the efforts of pisciculturists not having been very successful in impregnating the eggs (excepting with the white-fish) and hatching them out, although there would be no particular difficulty in regard to the alewife.

A second method, quite similar to the first, consists in simply collecting and penning up the mature fish in a suitable inclosure at about the time of spawning, and keeping them until the operation of reproduction is accomplished, but without taking any special charge of the eggs themselves.

The third is that especially practiced by the Chinese, of collecting the fertilized spawn, after it is laid, either by gathering it from localities under the water where it has adhered, or by straining it out while floating. The first method is in some instances assisted by introducing bunches of ozier or brush into the water frequented by the gravid fish, so as to furnish convenient objects of adhesion, and such as can be readily handled for the purpose of removing the eggs from them. The

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* From a very early time in the settlements of the different States, the transfer of live fishes has been attempted. One of the first species that attracted what was really a most mistaken interest was what is known as the pickerel, and represented by at least two species, the *Esox reticulatus* in the streams of the Atlantic slope, and the *Esox lucius* west of the Alleghanies. This must not be confounded with the so-called pickerel (the *Lucioperca americana*) of the Lake Erie shores.

This genus (*Esox*) is among the most ravenous of predacious fishes. They have a wide mouth, with a formidable armature of long, sharp teeth, and are long, slender, clipper-like creatures, swift in the water, where they are able to run down ordinary fishes, or, lying concealed, as is their habit, in the sedge and rushes at the edge of the clear channel, dart suddenly upon the passing fish. They are very bony, of indifferent flavor, and it is only where people are undiscriminating in their choice, from the lack of opportunity to compare them with better food-fishes, that they consider them desirable. They attain considerable size and take the hook eagerly, but their destructiveness of much superior fishes should condemn every effort to propagate them or to extend their distribution.

It is a singular coincidence that in earlier times in portions of Europe the same species as our western one (*Esox lucius*) was introduced into new waters rather extensively, and it is now acknowledged to be a most mistaken enterprise.

The commissioners of Maine have expressed their regret at the misguided enterprise of citizens of that State in introducing the pickerel into certain rivers and water-systems.

† One of the earliest experiments in the transfer of fish, other than pickerel and black bass, to new waters, was made by Governor L. J. Farwell, of Wisconsin. In 1854 he had one hundred fine, large white-fish carried alive to Madison and deposited in good condition in Lake Mendota in Dane County. A careful examination a few years later showed that they had increased rapidly, and occupied the deepest part of the water. In 1858 they appeared on the northeastern side of the lake, where they were caught in considerable numbers. A concurrent transfer of brook-trout into a tributary of the lake was not so successful.

eggs thus secured may then be transferred to any given locality and allowed to hatch naturally; or else beds are artificially prepared and attended until the birth of the young, when these are either allowed to escape into the water at once, or else they are fed for a short time, and then consigned to the ponds or streams which it is desired to stock.

All these methods are inferior in convenience as well as in economical results to the fourth, which is adopted by most fish-culturists throughout the world. This consists in taking up the fish when ripe, and, by suitable manipulation, in pressing out eggs from the body of the female into a dish, and then by repeating the operation with the male, so as to force the seminal fluid into the same vessel. In some cases the eggs and milt are stirred together in a certain amount of water; in others, what is called the dry method is adopted, a discovery usually credited to a Russian, M. Vrasski, in which no water is used with the eggs, but the milt is slightly diluted with water and poured upon them. By this method a much larger proportion of eggs is impregnated.* The movements preliminary to this treatment of the eggs taken from the living fish are also very varied. In many instances a careful watch is kept over localities where the fish are likely to spawn; and when the experienced observer notices that the operation of spawning is about to take place, he captures the usually inattentive pair by means of nets or other suitably-constructed apparatus, and proceeds with the work of exclusion and fertilization. This is said to be the principal method by which the eggs of the salmon are obtained in Germany and elsewhere for the national and private establishments, and is liable to the disadvantage of great uncertainty, and to a dependence upon conditions of the atmosphere and of the water that may materially interfere with the general result. Most of the doings in connection with the hatching of shad are of this nature; the seine being swept at a suitable locality, and the fertile fish stripped of their eggs and milt. This operation is always fatal to the shad, their delicacy of constitution not enduring such rough handling with impunity. It has also been adopted in some cases for salmon, having been employed by Mr. Livingston Stone in obtaining their eggs during the season of 1872.

The eggs of the white-fish and lake-trout are usually obtained at the fisheries, and the eggs after impregnation sometimes taken to great distances to be hatched. (See Mr. Milner's Report.)

A much more satisfactory and efficient method consists in inclosing the fish in pens or pounds until their eggs and milt are sufficiently matured to allow the process of artificial fecundation to be initiated. With trout

* Although M. Vrasski may have been the first to actually publish this method, Seth Green is said to have discovered it, keeping it a profound secret from his fellow-fish-culturists, who could not understand why so much larger a percentage of Green's eggs should be productive than of their own, although they followed strictly the method advanced in his treatise on fish-culture. This, however, made no mention of the dry process. The claim of priority in regard to the dry process has also been made in behalf of Carl Vogt. (See George P. Marsh on Artificial Propagation of Fish, Burlington, [Vt.,] 1857, p. 35.)

such an inclosure is usually permanent, but for salmon it is generally temporary. This treatment is also adopted with the white-fish which are taken in the Detroit River in the fall of the year, while running up to spawn from the deep water of the lake, placed in inclosures for marketing purposes, and kept there for sale, from time to time, during the winter. Indirectly, under these circumstances, they furnish the opportunity for artificial impregnation and hatching on a very large scale.

The simplest mode of obtaining salmon for the purpose in question is that adopted by Mr. Samuel Wilmot, at New Castle, Ontario. This gentleman, observing a few years ago that a few salmon were in the habit of coming up a small stream to a favorite spawning-ground, conceived the idea of penning them up so as to control them during the period of reproduction. He accordingly built a house over a basin in which they collected, or adjacent to the spawning-ground, and erected a dam below it, so that after they had passed above a gate could be dropped and the fish imprisoned. In this way he has been able to secure a large number of salmon, and with them has carried out, for the most part, his labors in connection with salmon-hatching.

A more feasible method, and one which can be conducted out on a much larger and more efficient scale, is that now practiced by Mr. Charles G. Atkins at Bucksport. This consists in securing the living salmon by any means at his command, the most ready being their purchase at the salmon-weirs at the mouth of the Penobscot River, where they are taken in considerable numbers and kept alive for any length of time. These are brought in suitable floating cars to Bucksport, transported on trucks to the hatching-establishment, and placed in a pond of about one hundred and fifty acres, where they find ample room for their movements.

The various methods of effecting the impregnation of the eggs has been already referred to, and the subject is treated of in detail by Mr. Milner in the appendix.

As already explained, it is not necessary to provide the breeding salmon with food, since they do not take it during the spawning-season; and they exist for the several months necessary to retain them with comparatively little mortality. Mr. Atkins's experiment was initiated in 1871. In 1872 he had nearly six hundred fish by the 1st of July, of which very few were lost. In the months of October and November he took from these fish 1,500,000 eggs, very few of the fish being injured in the process. They were then placed in the water and permitted to return to the sea, the precaution being taken to affix a metallic tag corresponding to the number, weight, and sex of the fish, and the date as recorded, so that if recaptured at any time some idea might be gained of their rate of growth, movements, and migrations.*

The eggs thus obtained, whether of salmon or of trout, are hatched

* For a full account of Mr. Atkins's experiment, see his report, p. 226 of the present volume.

out in contrivances which vary with the kind of fish, and which will be more especially referred to hereafter. Suffice it to say that those of shad are hatched in boxes which float on the water of the stream adjacent to the camp where the fish are captured and fertilized; this being accomplished within a week, and after a further detention of a few days, or until the yolk-bag is absorbed, they are turned into the middle of the stream at night while the predacious fish are most quiet or lying near the shore, and soon find hiding-places for themselves.

The eggs of salmon and trout require a period of from two to four months for development, this being in the winter-season. This process consists in placing them in boxes, with the bottom composed of parallel glass slats or of solid boards, lined with gravel, over which water of uniform temperature is allowed to flow continuously until the exclusion of the young takes place. Sometimes trays are used with wire-gauze bottoms, either singly or in tiers, and the water caused to flow either from above downward or the reverse. After this the young are sometimes transferred to some other receptacle until the yolk-bag is absorbed, when they are either introduced into rivers and streams or else retained in ponds and fed artificially for a greater or less length of time.

The key-note to the treatment of the anadromous fish lies in the now well-established axiom that each will always endeavor to return to spawn, if possible, to the very spot where it was first introduced into the water as a young fish, and that it will make every effort to accomplish this result; sometimes incurring even loss of life by persistent labor to this end. This is fully believed by all who have given attention to the subject, and in this we have the guarantee of success in any attempt to stock a particular body of water. It is true that the labor would in many cases be a profitless task, since the reaper might be, as already explained, and probably would be, a party having no interest in common with the sower. So universal, however, is the principle just enunciated, that we are assured that if three streams empty into the same bay on the coast, or are tributary to the same principal river, and all are equally eligible for the maintenance of anadromous fish, although destitute of them, one of these may be stocked and abound with fish, while the others which have been neglected will be almost entirely unvisited or will possibly become supplied very slowly and after a long period of time.

The existence of obstructions in a river, natural or artificial, is always detrimental in preventing the ascent of fish from the sea. If the young are introduced artificially into the headwaters, they will pass down after the proper period, and will remain in the sea for two or three and possibly sometimes for four years, when they will return, and, as already explained, use every effort in their power to reach their original station. If arrested at any point by an impassable dam, they will become the prey of such fishermen as have the right of access to them, while the upper waters will remain destitute and no captures be possible therein. For

this reason it is that the action of State or general governments in regard to the multiplication of salmon and other anadromous fish may even be carried on without any reference whatever to the existence of dams; and as far as the general interests of the community are concerned, it perhaps may be in many cases much cheaper to continue the artificial fertilization and development of the eggs, and the planting of the young in suitable waters, than to require the inconvenience and expense of removing artificial or natural obstructions or of inserting costly fish-ways. After the preliminary stages have been performed, the expenditure of a few hundred dollars a year will be sufficient to insure the presence of many thousands of shad and salmon in the lower waters of a given stream. Of course, to provide for the natural multiplication of the species and their equal division throughout the entire valley of the stream, the dams or obstructions must be regulated as already referred to.

19.—TREATMENT OF CERTAIN SPECIES.

The hatching of shad.

The boxes most generally in use at the present time for shad-hatching we owe to the ingenuity of Mr. Seth Green, and their introduction constituted an era in the art of pisciculture. The ordinary methods for the development of fish-eggs would not answer the purpose for the shad, and all attempts at hatching in the regular establishments would be practically a failure in consequence of the comparatively small number that could be managed by the usual methods, while an immense aggregate is required to produce even a moderate effect upon the supply in a stream.

The idea of a floating box is by no means new, such instruments having been used in Europe for many years, especially for hatching out the eggs of the *Cyprinidæ*, which adhere to whatever they touch, and require careful treatment. Mr. Millet used floating boxes in 1853 for hatching trout and salmon. The difficulty in hatching shad existed in the fact that when the boxes floated in the water so that the bottoms were horizontal, the proper circulation inside of the box was not established, and the eggs would spoil when exposed to the heat of the sun in consequence of their crowded condition. By the simple expedient of nailing two strips of board scantling parallel to each other, one on each side of the box, at an angle inclined to the bottom, the boxes are made to float obliquely in the water, since the strips themselves floated horizontally, and caused the bottom to be tilted up. The boxes are anchored with the inclination up stream, so that the current of water, striking freely against the inclined face of the wire gauze, which constitutes the bottom of the box, passes through it with a constant flow, producing the necessary motion in the eggs. By means of this device it has become possible to hatch shad by millions, where results would necessarily have been limited to thousands.

Several modifications of this box have been made, the most prominent of these being that invented by Mr. Brackett, and used for the first time in 1873. In this the box floats horizontally, but has the up-stream end beveled, and the water striking against it produces an eddy under the box, which causes a gentle agitation of the eggs. The details of this and some other constructions will be found in Mr. Milner's article in the appendix. None of them, however, can compare in simplicity and efficiency with Seth Green's apparatus.

In hatching the eggs of shad, much depends upon the temperature, and when the water is above 80° it is very difficult to bring them forward properly; indeed, the fish appear to experience a loss of vitality, and toward the end of the season apparently sound, ripe eggs fail to develop, notwithstanding every care. When, therefore, the stream reaches the degree of heat in question, the work is considered to be over for the year.

The hatching of white-fish, trout, salmon, &c.

An ingenious device has lately been patented by Mr. M. C. Holton, one of Mr. Green's assistants, for the purpose of securing the development of a large number of eggs from the trout, salmon, and white-fish in a limited space. Instead of placing a single layer of eggs in a long, narrow trough, he has prepared a can or box, of perhaps a foot square and several feet in height. This is filled with shallow trays of about half an inch in depth, with wire-gauze bottoms, on which the eggs are placed, so that with twelve trays, having a surface of one square foot each, he accommodates twelve times as many eggs as by the ordinary method. The box is so arranged that a current of water is carried by a covered pipe down the side of the can to the bottom and allowed to enter at that point. The current in its overflow passes from the bottom to the top, and the water circulates freely over the eggs. This arrangement has the additional advantage that once a day, or oftener if necessary, the trays can be taken out singly, and any diseased or defective eggs removed, thus improving the entire mass.

The eggs of white-fish require a long time for their development, like those of the salmon and trout needing from two to five months, according to the temperature of the water employed. The lower the temperature the longer the period necessary. The general theory of the development of eggs varies very much, according as they are smooth and non-adhesive, or coated with mucus which causes them to attach to each other or to other objects. The latter characteristic belongs to the *Cyprinidæ* in general, such as chubs and suckers, to the yellow perch, and many other kinds, for which reason it is extremely difficult to hatch these out. But little has been done in this country in that direction, and here the European culturists have the advantage of us. I owe to the kindness of Mr. Rudolph Hessel, one of the best of the German pisciculturists,

an account of the method of properly manipulating the adhesive eggs, which will be found in the appendix.

Fortunately the shad, striped bass, and the *Salmonidæ* generally, with perhaps only the exception of the smelt, have smooth or non-adhesive eggs, which permits them to be fertilized and readily manipulated without the inconvenience caused by their sticking together.

It is not my purpose to present here a treatise upon pisciculture in general, as I have nothing to add to the works already published on the subject, and which have been prepared by practical men of great experience. Among the most recent works are those published by Dr. J. H. Slack and Mr. Livingston Stone,* and in them will be found all the best-known methods of treatment, and especially for the trout. I hope, however, to present hereafter some special details in regard to other species that have been developed in connection with the operations of the United States Fish Commission.

The hatching of striped bass.

Nothing was known until recently as to the treatment of striped bass; but Mr. M. G. Holton, already referred to in connection with the improved apparatus for hatching the eggs of the *Salmonidæ*, while in the employ of Mr. Seth Green on account of the United States Fish Commission, at Weldon, N. C., took occasion to experiment with the spawn of several of these fish. To his surprise he found that it was non-adhesive, precisely like that of the shad, and capable of being treated in the same manner. The eggs were hatched out in four or five days, and with a small percentage of loss. They, however, were considerably smaller than those of the shad, requiring the bottom wire of the boxes to be much finer; twenty-two wires to the inch, at least, being needed.

It is unnecessary for me here to go into detail concerning the special method of treating the eggs of such fishes as the salmon-trout, the brook-trout, and other species, as these are discussed in detail by Mr. Milner in this volume, and are also considered at length in the various special American treatises.

Having thus presented a very brief indication of the history of multiplying certain of the food-fishes as practiced in modern times, and having explained the general principles of the method adopted for the purpose, I proceed to discuss more particularly the economical importance and history of the species of fish to which the attention of the commission has so far been more particularly directed, and of some of those which it is proposed to take up hereafter.

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* Practical Trout-Culture, by J. H. Slack, M. D. Orange Judd & Co., New York, 1872. Domesticated Trout: how to breed and grow them, by Livingston Stone, A. M. Boston, J. R. Osgood & Co., 1872.

D—FISHES ESPECIALLY WORTHY OF CULTIVATION.

1.—*The shad.*

Among these fishes, the American shad, *Alosa sapidissima* may be considered as holding the chief place, occupying in its distribution as it does the entire eastern border of the United States from the Saint John's River in Florida to the Gulf of Saint Lawrence, and even occurring in limited numbers in the waters emptying into the Gulf of Mexico. Its abundance in the early history of the country was such as to excite the unbounded astonishment of those who beheld it for the first time. With scarcely an exception, every river on the Atlantic coast within the limits mentioned was invaded in the spring by immense schools, which in their upward course furnished an ample supply of the best food, first to the aboriginal inhabitants, and then to their European supplanters and their descendants.

At one time it was imagined that the whole body of American shad, having wintered in the South, started northward with the new year, sending out detachments as they proceeded along the coast, first into one river and then into the next, until the last of the immense school made their way into the Saint Lawrence River. This idea, which attached equally to many other species of fish, is now believed to be in great measure at least incorrect; and it is thought more reasonable to suppose that the young fish, hatched in any particular stream, go out into the sea, and remain within a moderate distance of the coast until the period again recurs for their upward migration.* It may be however that a coastwise movement takes place to some extent.

* As a convenient place for the purpose, I introduce here an important contribution to the natural history of the shad, recently received from Mr. G. Brown Goode and Mr. Joseph Shepard:

"A knowledge of the occurrence of shad in the waters of the Saint John's appears to have been many years before the fishermen make any practical use of their information. Shad were not taken in quantity for the local markets until 1864 and 1865, though I am informed by Colonel Sammis, of Arlington, one of the oldest settlers of East Florida, that he knew of their capture in small numbers as early as the last Indian war (1839) and has since occasionally seen them. At that time the country was but sparsely settled, and there can have been little encouragement, and indeed little need for the use of seines, the inhabitants easily supplying their wants with the cast-net and the line.

"About 1859 or 1860 Mr. P. Waterhouse, a northern fisherman, introduced gill-nets and took shad in large numbers on the bar at the mouth of the Saint John's; these he shipped to northern markets, and it is said that he refused to sell a single fish in Florida, being angry with his neighbors for laughing at his project of catching shad in the Saint John's.

"All fishing was interrupted by the war, but immediately after its close gill-nets were extensively used and the shad were found to be very abundant. There can be little doubt that the species has inhabited the Saint John's for a great many years; the common idea that they are of recent introduction arises from the fact that through want of proper fishing they did not find their way to the markets till about ten years ago. The Saint Mary's River is still thought by many people living on its banks to be destitute of shad,

Nothing but impassable dams or natural falls prevented the fish from making their way to the headwaters of our rivers, and their

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though there can be little doubt of their occurrence there also. As there is no market near, there is no object in fishing for shad; but an old fisherman assured me that he found them abundant there many years ago.

"The Saint John's fishermen do not use shad-seines, though small seines are employed along the banks of the river and in creeks to take the smaller species of fish. They do not seem to appreciate the superior advantages of the seine, and aver that the swiftness of the current prevents its use. This is absurd since the current of the Conneeticut and other rivers, where seines are used to advantage, is much greater. As the present system fully supplies, and often gluts, the market there seems no immediate necessity for a change in the method of fishing.

"The gill-nets in use vary in mesh from three and one-half to four and one-quarter inches. They are about ten feet wide, and several gangs are fastened together so as to stretch nearly across the river, often a mile or more in width. The net is allowed to 'drive' or drift with the current, entangling in its meshes all the full-grown shad which it meets.

"The principal fishing-stations are near Mayport, on the bar at the mouth of the river, at Yellow Bluffs, and Trout Creek, respectively twelve and fifteen miles above, at Jacksonville, twenty-five miles from the mouth, and at Pilatka, a still greater distance up the river. Several nets are used at the head of the river, in Lakes Harney and Monroe and in Salt Lake, to supply the hotels there. The Pilatka fisheries are small and supply the local market. More than thirty nets are used in the neighborhood of Jacksonville, whence the fish are shipped, packed on ice in barrels, to Central Georgia and Florida, to the interior of Sourh Carolina, and to Alabama. Yellow Bluffs is another extensive market, and sends its fish to Savannah and the northern markets. The estimated total number of nets on the river is seventy-five.

"The largest haul of the past season was at Yellow Bluffs, where six hundred were taken from a single net; at Jacksonvile the largest haul was three hundred and twenty.

"The average price at the fisheries during the past season was 21 cents each.

"The hickory-shad (*Pomolobus mediocris*) usually makes its appearance in the Saint John's the first or second week in November; and as early as the 20th the first shad appear. The shad-fishing begins about the first week in December, and is at its best about the 1st of January. The season ends about the middle of April. At the time of my arrival, April 12, the last shad were in the markets. The herring (*Pomolobus pseudo-harengus*) accompanies the shad in great numbers, but is not caught much after the 1st of March. Two herrings or two hickory-shad count in the market for one 'white shad.' The dates given above are only approximate, taken from the memory of the fishermen and dealers; but as the testimony of the various persons interviewed agrees tolerably well, I believe them to be nearly correct.

"At the time of my visit the shad seemed to be in full spawning condition and were said to be very plentiful in the lakes of Central Florida, where the fishermen believe that most of them deposit their ova. At the time of their first appearance, the ovaries and spermaries are said to be barely distinguishable.

G. BROWN GOODE.

According to Professor Wyman the young shad, even as early as on the 1st of May, are met with in great numbers returning to the ocean and measuring three or four inches in length.

"The shad-season on the Saint John's, according to Mr. C. L. Robinson, of Jacksonville, is from the 1st of December to about the 8th of April.

"The first fishing done here for shad especially was by Captain Waterhouse, of Connecticut, two years before the war. The first year there were three persons engaged in the businsss as proprietors, working eight men and four nets. The next year there

diffusion was almost universal, so that few portions of the country east of the Alleghany range were destitute of their share.

The fisheries were established on the river banks, and the farmers living at a distance from the streams were in the habit of coming in their wagons to these stations and hauling the fish to their homes, and there preserving such as were not needed at the time, for the winter's use. Sometimes the early settlers in new towns, remote from the rivers, before roads were cut through the forests, having no more convenient mode of transportation, were in the habit of taking their fish in bedticks hung across the backs of horses, in some well-authenticated cases for as many as thirty miles.

The fisheries were originally prosecuted almost entirely by the use of seines; and although at any one place very few were taken compared with the numbers now captured in connection with the great modern contrivances employed for the purpose, yet in view of their occurrence in every river and its subdivisions, it is by no means imprcbable that

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was double that number engaged and some twelve nets, and so increased until a year ago; this last winter there were between seventy and eighty nets and over one hundred men employed from Pilatka down.

"Above Pilatka, particularly in the lakes, there were many more employed, say twenty.

"This last winter the business was about the same as the year before. It is estimated that about 500,000 were shipped from the Saint John's, mostly to Savannah. From Savannah they are distributed to various points north.

"In size those caught here are not as large as those in the Connecticut River.

"Our fishermen use a net of 4½ inches mesh, while in the Connecticut they use a 5½-inch mesh.

"They appear in our river coming in on their way to our upper lakes and creeks to spawn. When they come in they are fat and go into all parts of the river; but on their return, in June and July, they are very poor, and keep low in the deep water and follow the channel.

"Only a small portion of them return. It is thought they die of exhaustion, and are devoured by alligators and larger fish. The young shad go down to salt-water early the summer when they are about 1½ inches long. The fishermen are of the opinion that the shad have always been about as numerous as now in the Saint John's, but that the appliances for capturing them have been improved from year to year, and more persons engaged in it.

"The facts just presented are all from Mr. Robinson, and relate to the Saint John's River. I may say in addition, as regards our own waters, that there are a few shad taken every season in the Saint Mary's and Saint Illa by people living on those rivers for their own use; the net used being simply a hoop, 8 or 10 feet in diameter with handle 8 feet long, and held perpendicularly in the water by one man while another paddles the boat. When the holder of the net feels the fish against it, he brings it to the surface in the same manner as a scoop-net would be handled. From two to three and not unfrequently five or six are caught at one time in this manner. But I do not think that shad are as abundant in the above-mentioned rivers (which are narrow and deep) as they are in the (shoal and broad) river Saint John's

"Very respectfully, yours,

"JOSEPH SHEPARD,

"*Saint Mary's, Ga.*

"Hon. SPENCER F. BAIRD,

"*Commsssioner, Washington, D. C.*"

the aggregate actually caught every year was far greater than at present. Seines and scoop-nets being then the only apparatus used, they were, of course, by no means a match for the wholesale devices of seines miles in length, of wire gratings cutting off entirely the upward movement of fish, of slides, &c.

Little by little, impassable dams were erected at different points along our rivers and streams, and this was probably the first thing to check the natural increase of the shad; access to suitable spawning-grounds being an absolute necessity to the function of reproduction. In addition to this, the growth of cities and towns necessitated a larger supply to meet the demand, and more extensive apparatus was called into play, which not only captured a large proportion of each year's supply, but prevented the spawning of the remainder.

We may safely assume that to the exclusion of the fish from their breeding-places, or to their disturbance before reaching them, so as to prevent the discharge of their proper function in this respect, we owe the great decrease, and, indeed, the practical extermination in many localities, of this valuable fish. It is, therefore, sufficiently evident that whatever steps be taken toward the introduction or restoration of shad to our waters, this must be accompanied by appropriate legislation, which shall secure their freedom of access to the upper waters of the streams, and shall prevent the use of nets through the season continuously so as to allow none to escape.

Next to an actually unsurmountable dam, the most pernicious engine is that employed in some of the rivers in the South, consisting of a grating or net-work of wire, stretched from bank to bank, and forming an absolutely impassable barrier to the upward movement of the fish. They are, of course, arrested at this point, and while making fruitless efforts to ascend are captured by other nets set below.

Where the streams thus treated run partly in one State and partly in another, so that shad introduced by one State might be caught in another, the legislative interposition of the General Government would seem to be required.

Whether the causes herein suggested be actually those which have mainly affected the present reduction in numbers, there can be no question as to the fact of such decrease. During the spring of 1873, desirous of knowing exactly the basis upon which efforts might be made for the restoration of shad to the southern waters, and further transfer to western streams, I dispatched Dr. H. C. Yarrow on a tour of inquiry through the South, and his report is appended hereto, (page 396.)

The decrease proved indeed to be still greater than had been anticipated, and amounted to such a degree that on subsequently sending Mr. Seth Green and his parties to the Savannah River to prosecute their labors of shad-hatching, it was found impossible to procure enough spawning fish at Augusta, formerly the seat of a noted fishery, to carry on the work.

A similar state of things has existed, or at least until very recently, in the great majority of the rivers on our eastern coast, especially those north of the Potomac; and it is not to be wondered at, in view of the immense interests involved, that any suggestion of measures by which even a partial restoration of the abundance of shad may be accomplished, should be eagerly embraced.

The first efficient steps in reference to the artificial propagation of the shad appear to have been those of Seth Green, at Hadley Falls, in the Connecticut River, in 1867; but at a much earlier date a practical experiment was made looking toward the same general result. In the spring of 1848, Dr. William C. Daniel, of Savannah, now deceased, while at his plantation, ten miles from that city, was seized with the idea of attempting to introduce this fish into the Alabama River, and at once had a large number of shad-eggs squeezed out upon brown paper, and the milt of the male discharged over them. The eggs were dried, to what extent is not stated, and then sent by mail to Mr. Mark A. Cooper, at Etowah, in Cass County, who placed them in a small stream flowing into the Etowah River, a tributary of the Alabama, which, as is well known, discharges into the Gulf of Mexico. These eggs were carefully watched by Mr. Cooper, and after a time finally disappeared, allowing the inference that the young had passed away in the waters.

Up to that time, according to Dr. Daniel's testimony and that of others, shad were entirely unknown in the waters of the Gulf of Mexico; but in 1851 or 1852 some were taken in traps placed at the mouth of the Black Warrior River, near Tuscaloosa, Alabama, and also at the falls of the Alabama, near Wetumpka. In 1858, ten years after the transfer of the eggs, they were taken abundantly near Tuscaloosa, and since then have been regularly captured every year in greater or less numbers.

The ready inference from these statements is, of course, that the Alabama River shad referred to were the progeny of the spawn sent into its waters by Dr. Daniel. There is, however, considerable doubt whether shad-eggs, dried even to a slight degree and forwarded by mail, would retain sufficient vitality to mature. This, if true, might indeed furnish a practical suggestion for the more convenient introduction of the eggs into remote waters. The experiment might easily be made as to the vitality of the eggs under such treatment; and should this be established satisfactorily, we may unhesitatingly look upon Dr. Daniel as the originator of the experiments in regard to the transfer of this useful fish to new waters. In the appendix (page 387) will be found a series of letters from Dr. Daniel to myself, as long ago as 1860, having reference to this subject.

An additional fact in reference to the introduction of shad into tributaries of the Gulf of Mexico is furnished by Mr. William Gesner, of Birmingham, Ala., in a letter to the Atlanta Herald, in which he states that in the spring of 1858, in connection with Dr. E. R. Mordecai, of Mobile, and Mr. T. Hooker, of Montgomery, he placed 1,300 fish of

this species, and 7,000 eggs, taken from the Oconee at Milledgeville, and hatched out at Montgomery, in the Alabama River there; and that since that time they are caught in increasing numbers every year at Wetumpka, as also in Passalonga Creek, and at Eufala, on the Chattahoochee River.

As stated, it was in 1867 that the first precise efforts were made looking toward the increase of the supply of shad in any of our American rivers, this having been done in behalf of the fish commissioners of Massachusetts by Seth Green. He first treated the eggs as he would those of trout by placing them in hatching-boxes in a brook which emptied into the river. His experiment with several millions proved to be an entire failure; all the eggs spoiling before hatching. On examination he found that the temperature of the brook was thirteen degrees below that of the river, and he quite reasonably inferred that the water was not warm enough, and accordingly obtained some boxes, with wire gauze at the bottom, and allowed them to float on the surface of the river itself. To his great satisfaction, and that of his employers, the young were found to have hatched out at the end of three or four days, and swam about the boxes like the larvæ of mosquitoes.

This method answered a good purpose; but the percentage of loss was greater than Mr. Green considered satisfactory, mainly owing to the fact that the eggs were carried by the current to the lower end of the box and heaped up there, so that many were spoiled for the want of proper access to the water. By a happy inspiration he finally devised the hatching-box, to which reference has already been made, which is simply a wire-bottomed cubical box, with two slats nailed obliquely on each side, and floating on the water, so that the plane of the bottom shall be slightly inclined to the surface of the water, allowing the current to strike along underneath the entire length of the box, creating a slight eddy within, and causing a gentle agitation among the inclosed eggs.

Thus assured of success in the operation of hatching the eggs, the attention of many of the States was called to the advantages to be derived therefrom; and commissioners were appointed, charged with the duty, among others, of restoring the shad to the rivers. Massachusetts was followed in this effort by Rhode Island, Connecticut, and New York; in all of which very great success has followed their persistent labors in this direction. The most favorable situation for the purpose in question appears to be at South Hadley Falls in the Connecticut, where the impassable barrier of the Holyoke dam cuts off the upward movement of the fish, and permits them to be taken in great numbers. It is asserted by the Connecticut commissioners that in the spring of 1871 63,000,000 eggs were taken and fertilized; and in 1872 the enormous number of 93,000,000.

The data of the annual captures, here and elsewhere, will be found in an accompanying table, which contains an enumeration of the shad

hatched in the United States from the beginning of the enterprise to the end of the season of 1873.

The hatching of shad in the Connecticut River has been regularly prosecuted for several years past, although principally by the State of Connecticut. The only stream in which the work has been conducted continuously by Massachusetts is the Merrimack, in which several millions have been introduced each year since 1869, some of the fry taken here being transferred to adjacent waters.

In 1870 New York began her operations, and, as a first effort, introduced about 2,500,000 young fish into the Hudson, increasing the number every year since. It was found difficult to obtain a sufficient number of spawning fish as high up the river as Castleton, the station of the New York State shad-hatching camp; otherwise a greater approximation would have been made to the amount of work done on the Connecticut.

Nothing, I believe, has been done by New Hampshire in the way of increasing shad in her waters except by the transfer of several thousand eggs. But little has been accomplished by Maine.

In 1867 a fish-way was inserted in the Columbia dam on the Susquehanna, in Pennsylvania, to permit the upward passage of the fish, but no steps were actually taken to propagate shad until 1873, when the new commissioners established a camp at Newport, on the Juniata River, and succeeded in hatching out a considerable number.

As stated in the introductory portion of my report, the subject of national aid in increasing the abundance of shad and other useful food-fishes was first started in February, 1872, by a communication presented to the American Fish-Culturists' Association, at its meeting in Albany, by Mr. George Shepard Page.

The shad was, of course, a prime object in this application, and, Congress having responded to the appeal, the steps were taken which have already been detailed in a general way. As far as the shad were concerned, it was not considered necessary, or even proper, to make any effort in rivers belonging exclusively to one State, as it was considered the duty of such State to provide for its own food-resources. The prime object was to introduce the fish into the waters of the Mississippi Valley and into those of the Pacific coast, as also into the great lakes, since these waters are by their nature the common property of the Union, and, as already explained, where any effort on the part of a single State would, in all probability, inure to the benefit of those not resident within her borders; and it was not to be expected that any joint action would be brought about by which the result would be accomplished. Young fish introduced into the waters of the Upper Mississippi in Minnesota, or of the Ohio in Pennsylvania, would, in their return from the sea, traverse a large number of States, and, of course, be liable to be captured at any point before reaching their spawning-ground.

It was uncertain whether shad could be multiplied in the waters

west of the Alleghanies; but the cost of the experiment was so trifling compared with the benefits to result from a satisfactory solution of the question, that it was deemed best to make the trial.

I have already referred to the discovery of shad in the Alabama River, whether the result of Dr. Daniel's experiments already detailed or not; and I am assured by reliable testimony that they are found at the present time in other streams of Alabama. Of this I am well satisfied, having actually received a specimen from Mr. W. Penn Yonge, of Spring Villa, Ala., taken at Elba, Ala., and preserved in alcohol, and distinguishable in not the slightest particular from the shad of the eastern coast. I have also the assurance of Dr. Lawrence of their capture at the Hot Springs of the Ouachita; of Dr. Middleton Goldsmith, at the falls of the Ohio, near Louisville, and of Dr. Turner in the Wabash River of Indiana and Illinois, and in the Neosho River of Kansas. (See pages 391 *et seq.*)

I am not entirely satisfied that all these cases refer to the true shad, as there is a second species, found also on the eastern coast, known as the Tailor or Fall shad, which, while attaining nearly the same size as the true shad, is a totally distinct species, and very inferior in value. There seems, however, no reason why a young shad, hatched in the upper waters of the Mississippi Valley, may not make its way to sea and return again at the proper season. The distance to be traversed is probably a matter of very little consequence, as in former times shad penetrated to the very headwaters of the Atlantic streams, and exhibited no particular evidence of exhaustion. Starting at the mouth of the Mississippi, in the beginning of the year, and moving leisurely along, there would be nothing to prevent shad from reaching the upper waters of the rivers in the course of from two to four months' time. If they maintained enough vigor to deposit their eggs, the object would be accomplished, even though they were to die from exhaustion immediately after.

In illustration of what is here said in reference to the distance from the sea to which shad can penetrate, it may be remarked that among the most highly-prized fishes of China is a species of shad known among the European residents as the *Samlai*, which enters the Yang-tze-Kiang and the adjacent waters in May, and is in season for about sixteen weeks. By many persons it is considered to be even superior to the American shad, since, while of equally fine flavor, it is larger and more free from bones. According to the Chinese culinary authorities, shad should be neither boiled nor fried, its flavor and nutritious qualities being best preserved by being steamed, as is done by them with savory vegetables. By cutting the fish in transverse slices, the inconvenience of the bones is very greatly lessened. When first taken shad command fabulous prices, and, according to Dr. MacGowan, it is only the Emperor and the very highest officials who can procure them on their first arrival. They are then generally sold alive in tubs.

Besides the use made of the shad in China for food, it is highly

valued in the materia medica; the fish itself, and particularly its oil, being considered very efficacious in the treatment of consumption. Indeed, all the virtues which are usually ascribed to cod-liver oil are possessed, according to the Chinese, by shad-oil, and, in the opinion of Dr. MacGowan, there is a good deal of foundation for this impression.

The Yang-tze-Kiang, in which the shad is most abundant, is the largest river in China, having a length, as estimated, of 3,314 miles; and the shad are said to ascend almost to its source. This is a fact of very great importance in connection with the enterprise of stocking the Mississippi River and its tributaries with shad, since the distance from its mouth to the attainable waters of all the tributaries, excepting the Upper Missouri, is much less than that traversed by the shad of China. Indeed, a distance of about 1,500 miles from the mouth of the Mississippi would probably cover the extreme limit which the shad could profitably reach.

It is proper to state that while in the lower part of Yang-tze-Kiang the shad is highly valued as food, when it reaches the upper portions it is called "pestilence fish," from its alleged deleterious properties. This may be owing to the very extended journey which the fish makes in nearly the same latitude, (about 30° N.,) involving a great amount of exhaustion and consequent emaciation, while, of course, the temperature of the water becomes more and more elevated with the advance of the season. The case is quite different with the Mississippi River and most of the shad-producing rivers of the Atlantic coast, the direction of which is more nearly north and south their sources being in a considerably higher latitude than their mouths, so that the fish entering them at a certain season, and passing slowly up, would about keep pace with the progress of the season, and not be subjected to extreme heat until after the actual spawning-period had passed, when, as is well known, all fishes are more or less unfit for food.*

According to Dr. Day, India possesses a migratory shad, which ascends the rivers for breeding purposes, like the American species in the United States. This is known as the *Alosa palasah*, and in Madras is called the sable-fish. These appear to ascend the rivers at a different season from our own fish, and generally to breed at the commencement of or during the monsoon. The main body of the shad begins to ascend the Kistna River about the middle of October, and disappears by April. In the Godaveri they ascend earlier, being most abundant from

* Although not bearing on this subject, it may be of interest to state that in the article from which we derive these facts, Dr. MacGowan informs us that the different species of sea-weeds, especially of a *Laminaria*, are considered to be efficacious in goitre, swellings of a scrofulous character, and cutaneous eruptions, those richest in iodine being valued most. There is a popular belief in regions where mineral coal is employed for fuel, that sea-weed is an indispensable corrective against the noxious fumes of the coal-fire. (Journal of the North China Branch of the Royal Asiatic Society, VII, 1873, 235.)

July to September, after which the fishermen believe that they migrate to the Kistna. In the Hoogli they continue ascending throughout the southwest monsoon, and some are found full of roe in September. They occur at Mandalay in Upper Burmah at the end of the year. In Sind they about February and descend about the end of September, after which none are met with. They are found in the rivers, usually during the periods of the flood, when their instincts or traditions inform them that the shallows are covered with water, so that they can proceed upward to their destination. In the Irawaddy they push on as far as Upper Burmah.*

Shad, in their ascent of the Mississippi, would have no falls and no current of inconvenient strength to overcome, and it would seem no more difficult for them to swim up the river than to sweep along in schools from one part of the coast to the other. Although they do not feed in fresh water, the privation of food for several months would be no serious inconvenience, as fish are frequently longer than that without sustenance. Starting, as they would, full of fat, the moderate expenditure required for this period of time would still leave enough to supply the substance for the ripening of the eggs and of the milt. For these reasons I am entirely satisfied, as are most persons who have given attention to the subject, that shad introduced into the upper waters of the Mississippi may be taken there again in the same vicinity as mature fish; provided, of course, that they are not destroyed, intercepted. And even should the entire range of the Mississippi and its main tributaries be too much for them, the uncertainty diminishes as we reduce the distance from the Gulf, and we may consider success assured in the shorter rivers, emptying directly into the Gulf and in the lower waters of the Mississippi and Missouri, at least from the mouth to the Ohio.

One great argument in favor of the attempt to introduce the shad as well as species of salmon into the Mississippi River and its main tributaries, is the general absence of dams as compared with the waters of the Atlantic coast. There is, even now, nothing to prevent fish from running up to a great distance, even to places where excellent opportunities for spawning can be had.

The question has been asked whether, admitting that the shad and salmon can live and propagate in the waters of the Mississippi Valley, they will not find the Gulf of Mexico too shallow and hot for them. To this we have the satisfactory reply that the recent researches of the Coast Survey show, directly outside of the mouth of the Mississippi, an immense area where the depths range from 1,200 to 6,000 feet. The temperature below 600 feet ranges from 35° to 29°, even in summer, due probably to the intrusion of the cold water from the Antarctic region in passing along the floor of the Atlantic Ocean.

The question of food, of course, does not come into account, as we have already explained that the shad does not feed in the fresh water;

* Fresh-Water Fisheries of India and Burmah, by Dr. Day, 22.

the examination of, we might almost say, millions of stomachs of fish, taken above the mouths of rivers, revealing nothing whatever in the way of food, or in a very few instances only. Four cases only have come to my knowledge where any food was detected, and that only within a short distance of salt-water. Once returned to the ocean, the shad feed voraciously; and although extremely thin and emaciated when emerging from the rivers, they soon fatten up.

It is not very often that shad are taken in the sea, but they are captured in large numbers in the Bay of Fundy in autumn, after returning from their spawning-operations in the Saint John and other streams. They are then taken in weirs, and are claimed to be of unsurpassed excellence o flesh.

Once in the sea, of course there is no limit to the amount of food they can obtain, this consisting of worms, small fishes, and most largely of minute crustaceans, especially of the genus *Mysis*.

The problem as to the possibility of naturalizing the shad in the great akes, so that they may subsist there the greater part of the year and find a supply of food, is more difficult of solution and one that can only be decided by experiment. We have, however, the interesting fact that the deep waters of the great lakes abound in certain species of minute crustaceans, precisely similar to those occurring on the Atlantic coast, and which, while consumed to a great extent by the white-fish, may be presumed to be in sufficient surplus to feed an indefinite number of shad. The experiment of stocking the lakes with shad has been already made by Seth Green, who planted 15,000 in the Genesee River, near Rochester, in 1871. A number of these were subsequently taken in nets, and it is thought probable that the spring of 1874 will witness the movement of mature fish up the Genesee River.

It is proposed also to try the experiment of introducing young shad into the Great Salt Lake of Utah by placing the young in the Jordan River; indeed, a beginning has already been made by the planting of 5,000. It is true that the water of the lake is excessively saline; but there is a large region adjacent to the mouths of the tributary streams, more or less diluted, and it may be that the fish on running down into the lake can gradually accustom themselves to its great density and concentration. They will, at any rate, not suffer from want of food, since the *Artemia* (a crustacean) and sundry dipterous larvæ are found in enormous numbers.

A similar reasoning applies to the question of introducing salmon, alewives, lobsters, oysters, &c., into the same waters.

The experiment of placing shad in the Sacramento River, already mentioned, initiated in 1871 as it was by the California State commissioners, with the help o Seth Green, and continued in 1873 by the United States Fish Commission, through Mr. Livingston Stone, may be considered as an actual success.

As already stated, the experiment of artificial propagation of shad

was not only made first in the Connecticut River, but also on a larger scale than elsewhere; and the results of the experiment of 1867 were seen as early as 1870. To the confusion of the incredulous, schools of shad in immense numbers were seen in the spring in Long Island Sound, all making their way to the Connecticut River, and on the 23d of May over 2,800 were taken from a pound near Saybrook. At another pound 3,560 were taken, and elsewhere they were caught in numbers varying with the locality. The largest haul previously on record was in 1811, when 2,280 were caught at one time, although a draught of 2,300 was reported at Haddam Pier in 1802.

The abundance of shad in the river in 1871 was still greater than in the previous year, so much so, indeed, that in the time of greatest plenty they could scarcely be disposed of at the rate of $3.50 per hundred. At the present period the increase has been such that numerous fishing-stations, for a long time abandoned, have resumed operations with very satisfactory results.

A great increase in the number of shad has also manifested itself in the Hudson and the Merrimac, and with a reasonable continuance of effort there is every reason to expect that the pristine abundance of fish will be restored, and possibly even increased, if young shad are hatched out in sufficient number.

2.—*The alewife or fresh-water herring.*

I am inclined to think, for various reasons, that too little has been done in our waters toward the restoration to their primitive abundance of the alewife (*Pomolobus mediocris*), the herring of our Southern and Middle States; not to be confounded with the sea-herring, (*Clupea elongata.*) It is better known as the alewife throughout New England, and is the gaspereau of the British provinces. Like the shad, it ascends from the ocean in early spring into the fresh or brackish waters, and has the advantage of breeding in quiet ponds, instead of requiring a river for its development. In former times, and before the introduction of dams across the streams, this fish was very abundant along the coast, and supplied an important article of food to the people, both fresh and salted.

The alewife in many respects is superior, in commercial and economical value, to the herring, being a much larger and sweeter fish, and more like the true shad in this respect. Of all American fish none are so easily propagated as the alewife; and waters from which it has been driven by the erection of impassable dams can be fully restocked, in the course of a few years, simply by transporting a sufficient number of the mature fish, taken at the mouth of the stream to a point above the dams, or placing them in ponds or lakes. Here they will spawn, and return to the sea after a short interval, making their way over dams which carry any flow. The young alewives after a season descend, and return, if no

prevented, at the end of their period of immaturity, to the place where they were spawned.

In addition to the value of the alewife as an article of food, it is of much service in ponds and rivers as nutriment for trout, salmon, and other valuable fishes. The young derive their sustenance from minute crustaceans and other objects too diminutive for the larger fish, and in their great abundance are greedily devoured by the other species around them. In waters inhabited by both pickerel and trout, these fish find in the young alewives sufficient food to prevent their preying upon each other. They are also, for the same reason, serviceable in ponds containing black-bass.

As a cheap and very abundant food for other fishes, the young alewives can be placed in waters that have no connection with the sea by merely transferring from any convenient locality a sufficient number of the living mature parents, taken at the approach of the spawning-season; they will remain for several months, and, indeed, can often be easily penned up by a suitable dam and kept throughout the year.

It is in another still more important connection that we should consider the alewife. It is well known that within the last thirty or forty years the fisheries of cod, haddock, and hake, along our coast, have measurably diminished, and in some places ceased entirely. Enough may be taken for local consumption, but localities which formerly furnished the material for an extensive commerce in dried fish have been entirely abandoned. Various causes have been assigned for this condition of things, and, among others, the alleged diminution of the sea-herring. After a careful consideration of the subject, however, I am strongly inclined to believe that it is due to the diminution, and in many instances to the extermination, of the alewives. As already remarked, before the construction of dams in the tidal rivers, the alewife was found in incredible numbers along our coast, probably remaining not far from shore, excepting when moving up into the fresh water, and, at any rate, spending a considerable interval off the mouths of the rivers either at the time of their journey upward or on their return. The young too, after returning from the ocean, usually swarmed in the same localities, and thus furnished for the larger species a bait, such as is not supplied at present by any other fish, the sea-herring not excepted. We know that the alewife is particularly attractive as a bait to other fishes, especially for cod and mackerel. Alewives enter the streams on the south coast of New England before the arrival of the blue-fish; but the latter devote themselves with great assiduity to the capture of the young as they come out from their breeding-ponds. The outlet of an alewife-pond is always a capital place for the blue-fish, and as they come very near the shore in such localities, they can be caught there with the line by what is called "heaving and hauling," or throwing a squid from the shore, and hauling it in with the utmost rapidity.

The coincidence, at least, in the erection of the dams, and the enor-

mous diminution in the number of the alewives, and the decadence of the in-shore cod-fishery, is certainly very remarkable. It is probable, also, that the mackerel-fisheries have suffered in the same way, as these fish find in the young menhaden and alewives an attractive bait.

The same remarks as to the agency of the alewife in attracting the deep-sea fishes to the shores, and especially near the mouths of rivers, apply in a proportional degree to the shad and salmon.

As indicated in a previous page, the usual method of multiplying the alewife consists in transferring the mature and spawning fish alive to the waters which are to be stocked. There they spawn in the spring, and with the young return in autumn to the sea. They will thrive in the brackish ponds along the coast, in rivers, and in small lakes; unlike the shad, preferring the quiet bodies of water rather than running streams. Little or nothing of any magnitude has been done in the way of artificial impregnation and hatching of their eggs, although a matter of no special difficulty.

There seems to be a difference of opinion as to the age at which alewives first return from the sea, some fixing it at two and others at three or more years. Capt. Treat, of Eastport, however, many years ago transported several hundred pairs of breeding-fish to a small sheet of water, known as Keene's Pond, situated some five or six miles from Robbinston, Me., and having its outlet into the Calais River just below Red Beach. The level of the lake is several hundred feet above that of the river, and the outlet is very precipitous, consisting of several falls entirely impassable to fish from below. No alewives had ever been known in this pond at the time of their introduction by Captain Treat. The young fish were seen in the pond in the course of the summer in myriads, all of them disappearing, however, after a heavy rain in the autumn, which swelled the waters to produce a sufficient discharge. Due examination was made for successive years, but not until the expiration of the fourth were they seen, when the outlet was observed to be almost choked up by a solid mass of alewives, struggling to make their way back again to the place of their birth.

3.—*The salmon of Europe and New England (Salmo salar).*

Among the fish, the multiplication or artificial increase of which has most occupied the attention of governments, the salmon (*Salmo salar*) is pre-eminent. The species is believed to be the same on the Atlantic shores of both America and Europe. It is true that the aggregate of effort in reference to the increase of trout, both in America and Europe, may be greater; but certainly the smaller species of the *Salmonidæ* are very much inferior in actual commercial value to the true salmon. An account of the measures taken to multiply this fish in America, including the various methods of hatching, &c., will be found summarized in Mr. Milner's article, and in those of Messrs. Stone and Atkins.

The interest in the preservation and increase of the salmon is due, in the first place, to its reputation as a game fish, and the sport experienced capture; but, perhaps, still more to its great size and economical value. No fish of its magnitude brings so large a price per pound, and is so universally regarded as a chief delicacy. It abounds in all the waters of the North Atlantic, both in Europe and America. Making its home in the sea, it passes into fresh water at periods varying with the locality, sometimes early in the winter, and again not until spring; and after remaining some months in the rivers, it seeks a suitable spawning-bed, where the eggs are deposited; after which the adults either return to the sea, or in some instances, as in Nova Scotia and New Brunswick, pass into the fresh-water lakes, and spend the winter and early part of the spring.

The eggs occupy from two to four months in their development, and the young are hatched in early spring and remain in the rivers for at least one year. There is evidence that a portion remain until the second year, this being especially the case with the female. Then, passing down to the sea as fish weighing a few ounces, they remain there several months, and return in autumn as grilse of several pounds. These are said to go back to the sea again before winter sets in, and to return the next season, as breeding-fish, weighing perhaps eight or ten pounds each. The growth of these fish is very rapid; and as this takes place in the sea, without the necessity of artificial feeding, it may be readily imagined how valuable a salmon fishery is likely to be, compared with one of trout, which, to be of any special economical importance, requires the constant feeding of the fish.

I do not at present propose to attempt a detailed biography of the salmon, as the facts at my command in reference to that fish, in America, at least, are not yet sufficient to warrant my doing so. The articles in the appendix, by Messrs. Stone, Atkins, and others, will, however, be found to contain much valuable information.

As to the important point of the period of their abode in the sea, authorities differ, but it is now the general impression, as already stated, that the male fish are mature frequently in three years, and that all are certainly so at the expiration of four years from birth.

The salmon is emphatically a fish of New England and the British provinces, and never belonged to any of the States south of that section of country. The Connecticut River is believed to have been its western limit on the Atlantic coast, as shown by the testimony of Douglass and others,* although some extend their range to the Housatonic. They were also abundant in Lake Ontario and Lake Champlain.†

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*Douglass, William. A summary, historical and political, of the first planting, progressive improvement, and present state of the British settlements in North America. 2 vols., 8 vo. Boston, 1749–'51.

On p. 212, he says that salmon are a high-latitude fish, not to be found south of New England; the farther south, the later they set in, and continue a shorter time;

From a very early period, the preservation of the salmon-fisheries in Europe, or their restoration when exhausted, has occupied a great share of attention. The problem has perhaps been most carefully worked out in Great Britain, where in numerous localities, formerly exhausted, this fish has been restored, to the very great profit of those who control the streams. So far from being a luxury now, unattainable by any but the wealthy, salmon have become a staple fish of Great Britain, and are to be had in the season at prices very little more than are paid for ordinary kinds.

The history of the introduction of salmon into Tasmania exhibits an instance of enterprise highly to be commended, especially when we bear in mind the fact that it was necessary to transport the eggs over sixteen thousand miles of ocean, during a period of many months, involving an exposure to tropical heat; but which was actually accomplished with a percentage of loss scarcely greater than that at the celebrated establishment at Hüningen. The first experiment in this direction was made in 1862, and, according to Mr. H. R. Francis, failed from an insufficient supply of ice. The eggs were packed between layers of moss, in boxes, which were suspended, in order to break the motion of the ship. A small stream of ice-water was made to flow over them to keep them of a proper temperature. They were thus maintained in good condition for eighty days, during which time they passed through the tropics. But the supply of ice failing, the eggs all died.

Ultimate success was hoped for, however, from the result of an experiment made in an ice-house in London, where eggs, kept for periods from forty-five to one hundred and forty-four days, were afterward hatched out into vigorous fish.

In 1864 a more successful trial of sending eggs to Tasmania was made. The eggs were packed between layers of moss, as before, being stratified with successive layers of moss, ice, and charcoal, in boxes perforated

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for instance, in Connecticut River they set in beginning of May, and continue only about three weeks; in Merrimac River they set in beginning in April to spawn, and lie in the cold, deep brooks until September and October, then silently, so as not to be observed, and with dispatch, they return to the sea. In Chebucto, Cape Breton, and Newfoundland they continue the greatest part of the year.

† Williams, in his History of Vermont, 1809, vol. 1, p. 147, remarks that "the salmon begins to pass up Connecticut River about the 25th of April, and proceeds to the highest branches; and that about the same time, or a little later, they are found in Lake Champlain and the large streams which fall into it. When going up in the spring they are round and fat, and of an excellent taste and flavor, and are taken in great numbers from the first week in May to the second week in June. When they arrive at the upper parts of the rivers, they deposit their spawn and remain there during the summer-season, but become very lean and flaccid. Toward the latter end of September they return to the sea, but so much emaciated that they are not taken or used for food. Some of these salmon in the spring will weigh thirty-five or forty pounds. They migrate only to cold waters. None of them are ever found to the south or west of Connecticut River. Those that go farther to the northward and pass up the river Saint Lawrence are generally more large and rich than those which come from the southward."

all over for the free admission of air. The eggs were thus kept from direct contact with the ice, but blocks of ice were placed over the boxes. The eggs were never actually frozen, although maintained at a temperature not far from 32°. An ice-house was built in the vessel, and the eggs were undisturbed from the beginning to the end of the journey. The transfer was made on the ship Norfolk, 50 tons of space being assigned for the purpose.

The eggs, to the number of about 100,000, were collected by Mr. Youl, and contributed voluntarily by various gentlemen in England. The vessel sailed on the 21st of January, and cast anchor in Hobson's Bay on the 15th of April. The ice-house was then opened for the first time since it had been closed on the Thames, and a large portion of the contents proved to be sound and in good condition. Strong wooden boxes were then prepared, in each of which about fifteen of the small original boxes of eggs, covered with a considerable thickness of ice, and wrapped in blankets, were securely packed. Eleven of these larger boxes, containing in all 170 of the English boxes, were then transported to Hobart Town, and eleven were retained by the Acclimatization Society of Victoria. On the 20th of April the Hobart Town eggs reached their destination, and were carried up the Derwent River to New Norfolk, and thence to the ponds prepared for them on the little river Plenty, about seven miles distant. The ova were immediately placed in the gravel of the hatching-boxes, and a stream of water directed over them, which for a time was cooled by the remainder of the ice; afterward, however, the water supplied was of the natural temperature. The number of healthy eggs placed in the pond was estimated at about 14,000, and the first embryo hatched out on the 4th of May.

In 1866 a second consignment of about 93,000 salmon-eggs was shipped to Tasmania, and, after a voyage of one hundred days, they reached their destination in Hobson's Bay on the 1st of May, and were forwarded to the hatching-house on the river Plenty, as before. About 30,000 eggs were found to be healthy, from which they succeeded in obtaining about 6,000 young fish.

The young fry hatched in May, 1864, were discharged from the pond as smolts toward the end of 1865, while the next lot, about 6,000 in number, was let out in September or October, 1867. Descending the Plenty into the Derwent River, they had a few miles of fresh water before reaching the estuary above New Norfolk. The experiment is believed to have been entirely successful, though it was not until 1874 that a specimen was taken of what is believed to have been a genuine salmon-grilse, actually born in Tasmania.

Corresponding experiments were carried on with reference to the English sea-trout, which proved entirely successful. This fish is now actually acclimated in Tasmania, and propagates naturally in the Derwent River, where specimens are constantly taken for the table, some of them weighing as much as seven pounds.

An interesting experiment was tried on this occasion as to the possibility of retaining the sea-trout in fresh water throughout the entire period of their existence, about fifty of them being used for the purpose. This has succeeded perfectly, the original stock having bred for five years in succession in fresh waters.

The history of the efforts in the United States, looking especially toward the restoration of salmon to American waters, may perhaps be considered as dating from a report upon the artificial propagation of fish made in October, 1857, to the general assembly of Vermont, by the Hon. George P. Marsh, now United States minister to Italy, almost simultaneously with one by Mr. A. H. Robinson, of New Hampshire. It was not until 1864 and 1865 that the fish commissioners of the New England States took measures to accomplish the desired object, and, according to Dr. Edmunds* and Mr. William Clift,† the first positive effort was made by Dr. Fletcher, of Concord, N. H., in 1866, who visited New Brunswick for the sake of transferring adult fish alive to the New Hampshire streams for the purpose of restocking them.

Dr. Edmunds, however, remarks that, according to Mr. Thaddeus Norris, James B. Johnson, of New York City, procured eggs of a salmon (*S. hucho?*) in 1864, and hatched them in New York City by Croton water; but that they all died when liberated.

According to Genio C. Scott, ‡ Seth Green, by his advice, made application to the French establishment at Hüningen, in 1865, for some salmon ova, and was presented with 20,000 in the spring of 1866, which were properly packed and shipped. They were, however, delayed in the New York custom-house until they died.

Dr. Fletcher went again to New Brunswick in September of 1866, and brought home 25,000 impregnated ova, of which a large number were placed in the Merrimac River after being artificially hatched, and, with the exception of a few, they were treated for this purpose in Concord. Whether the remainder hatched out or not it is impossible to say; but we may safely consider the date of March, 1867, as the first period when artificially-hatched American salmon were introduced into American waters; namely, in the Pemigewasset, at Compton, N. H., by Dr. Fletcher. In 1867 Dr. Fletcher again visited New Brunswick, and brought home, as he supposed, 100,000 eggs or more. Half of these were distributed to the New Hampshire commissioners, Robinson and Hoyt, at Meredith N. H., and the other half to Livingston Stone, at Charlestown. The entire yield of these eggs was about 5,000 of each lot, or 10,000 in all.

In 1868 Mr. Livingston Stone, in behalf of several parties, built a salmon-breeding establishment on the Miramichi River, New Brunswick,

*Introduction of Salmon to American Waters: Proceedings of American Fish-Culturists' Association, 1872, p. 32.

† Salmon and its Culture, 1872, p. 19.

‡ Fishing in American Waters. New York, Harper and Brothers, 1869.

and brought home 182,000 eggs, which were hatched in various localities, principally at his establishment in Charlestown, N. H. Some were hatched by Mr. Brackett, one of the commissioners of Massachusetts, and turned into the Merrimac River in that State. Others were introduced near Cape Cod. Two thousand of the young fish, of the lot hatched by Mr. Stone, were introduced into West River and the Winooski, in Vermont; and a few of the lot were subsequently identified.

In 1869 Mr. Hagar, of Vermont, obtained 4,050 of the eggs from the Miramichi, 80 per cent. of which were hatched out at Chester, Vt., and introduced into tributaries of the Connecticut.

In 1870, according to Dr. Edmunds, 8,000 eggs were sent to him from the Miramichi River, which were distributed to the commissioners of Maine and Connecticut; Mr. Clift, of Mystic Bridge, also received a few.

In 1870 the fish commissioners of Maine and Connecticut purchased from Mr. Wilmot's establishment, at New Castle, Ontario, 18,000 eggs, which were hatched and distributed.

In 1871 Maine, Massachusetts, and Connecticut jointly built a salmon-breeding establishment on the Penobscot River, at Orland, placing it under the charge of Mr. Atkins; and from this a reasonable supply was received. The first operations for hatching fish on a large scale were those of Mr. Atkins, at Bucksport, in Maine, in 1872, when the aggregate subscriptions of the States were supplemented by an equal amount furnished by the United States Fish Commissioner, (page xviii.) It would therefore seem, as stated by Dr. Edmunds, that it is to Dr. William W. Fletcher, of Concord, that we owe the first practical success in introducing salmon into American waters, before destitute of them, by transferring the properly-impregnated ova from localities where they abound to salmon-breeding establishments, whence they were distributed to their destination. It is, however, to the method adopted by Mr. Atkins, (whether his own device, or that of some one else, I am unable to say,) in penning up the mature fish, on their entrance into the rivers, and keeping them until their eggs are ripe, that we owe the possibility of carrying on the work on a large scale.

A dependence upon the salmon-eggs to be furnished from British or Canadian waters would have been entirely futile, since the authorities as well as the people of the Dominion have always looked with great jealousy upon the efforts made by the United States to obtain eggs within their borders, this, in fact, having been prohibited by positive enactment. It was, therefore, only within the waters of the United States that such efforts could be carried on without interference, and the plan referred to, of penning up the fish and keeping them, has placed within our power the means of securing, with the least possible trouble and expense, as many eggs as can conveniently be manipulated.

To bring up the history of American salmon-culture to the date when

the isolated efforts of the States were supplemented by the more comprehensive co-operation of the General Government, Dr. Edmunds remarks that from the first salmon-fry introduced into the Merrimac River no returns have been realized. Some were seen and taken going to sea, but none have returned. Some ripe salmon were taken, however, at Holyoke, in the spring of 1872, and at Saybrook, at the mouth of the Connecticut; but, in his opinion, it is in vain to expect much in the way of actual results, in most of the streams, at least, until legislative enactments and the force of public opinion have caused the erection of suitable fish-ways in the dams.

In the earlier part of the present report (p. xviii) will be found an account of what has been done in the way of multiplying the Maine salmon, under direction of the General Government, beginning with 1872.

The most serious artificial obstruction in any of the American rivers to the upward movement of the salmon, as well as other fish, so far realized, has proved to be the Holyoke dam at South Hadley Falls; and a persistent effort has been made for many years, by the commissioners of Massachusetts, aided by those of other States, to cause the powerful corporation owning the dam to introduce a proper fish-way. An act of the Massachusetts legislature requiring this to be done was contested by the company, the suit being carried successively to the supreme court of the State, and then to that of the United States. Beaten at all points, the company has finally yielded gracefully to the necessity, and is now actually engaged in erecting a fish-way, devised by Mr. Brackett, one of the fish-commissioners of Massachusetts, in accordance with the unanimous recommendation of the commissioners of all the States through which the Connecticut River flows.

It will be sufficiently evident that the extent to which the restoration of salmon can be made to American waters will depend very largely upon the character of the obstructions, whether natural or artificial, which the fish must overcome; and, in order to have at hand all the data possible in this connection, I requested Dr. M. C. Edmunds, one of the fish-commissioners of Vermont, and the author of the valuable report from which I have just quoted, to make a special tour of Lake Champlain and the south side of Lake Ontario, with a view of ascertaining the best localities for the introduction of salmon and the character of the obstructions in the rivers. This he has performed faithfully, and has furnished a detailed report on the subject, with a map, which will be found appended.

About the same time Mr. Stilwell, one of the commissioners of Maine, prosecuted a similar inquiry as to the obstructions in the rivers of that State. His report and accompanying map are also given herewith. Corresponding information of the same character in regard to the James River in Virginia, as also for streams in Wisconsin and Michigan, tributary to Lake Michigan, has also been received; and, with what is being furnished from other localities, I hope to be able to present before

long a map of the United States showing the points where efforts must be directed toward opening the streams for the upward movement of fish.

Salmon were at one time very abundant in Lake Champlain and Lake Ontario, even within the memory of persons now living;* but their upward course in the great lakes was always barred by the Falls of Niagara. Now they are apparently unknown in either body of water, except on the Canadian side of Lake Ontario, where the judicious methods adopted by Mr. Wilmot, at Newcastle, have largely increased their numbers, and have enabled him, under direction of the government, to furnish a supply of eggs and young to adjacent waters in the provinces, and even to a limited extent to parties in the United States.

Much contrariety of opinion has been expressed as to whether the salmon of Lake Ontario really run to the sea, or whether the lake is to it an ocean in which it finds the necessary subsistence, except when moving up the streams to spawn. The size is rather less than that of the ocean salmon, but it is otherwise undistinguishable. Whether this be the case or not, there is not much question as to the possibility of keeping Lake Ontario supplied with salmon, provided obstructions to the passage of the fish to suitable spawning-grounds in inflowing streams be obviated by suitable fish-ways.

As far as the lakes above the falls are concerned, nothing can be determined without experiment; but it is extremely probable that enough of these fish might remain, without descending the falls, to establish a special stock. We know that the temperature of Lakes Michigan and Superior, of which we have the best information, amounts, at a depth of 145 fathoms, to 45 degrees in September, in the one, and to 39 degrees, in depths of over 40 fathoms, in the other. We also know that all the lakes abound to an enormous extent in minute crustacea, especially of the genus *Mysis*, which is undistinguishable from a species which in the North Atlantic is believed to furnish in large part subsistence to the salmon. It is upon this and two or three species of the *Gammarus* that the white-fish feeds, and it is not improbable that both salmon and shad

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* Watson, in his history of Essex County, N. Y., speaking of the fish in Lake Champlain, says: "The early settlers of the valley of Lake Champlain found the streams upon both sides filled with salmon. They were very large, and among the most delicate and luscious of all fish. All that period they were abundant, and so fearless as to be taken with great ease and in immense quantities. A record exists of five hundred having been killed in the Boquet in one afternoon, and as late as 1813 about fifteen-hundred pounds of salmon were taken by a single haul of a seine, near Port Kendall. They have been occasionally found within the last twenty years, in some of the most rapid streams, but have now totally disappeared. The secluded haunts they loved have been invaded; dams have impeded their wonted routes; the filth of occupied streams has disturbed their cleanly habits, and the clangor of steamboats and machinery has excited their fears. Each of these causes is assigned as a circumstance that has deprived the country of an important article of food and a choice luxury. The subject is not unworthy the inquiry and investigation of the philosopher of nature."

may find them in so great abundance as to keep themselves in good condition, and obviate the necessity of going elsewhere in search of food.

In the eastern portion of North America, in addition to the true *Salmo salar*, some writers maintain the existence of a second species, which they call *Salmo hamatus*, or hook-billed salmon, and which they distinguish by the development of a hook in the lower jaw. Whether there be two species or not, there is no question that the true salmon has this development during the spawning-season to a very great degree, and therefore it cannot constitute a distinctive mark.

4.—*The western salmon* (*Salmo quinnat ?*).

It is on the west coast of North America alone that salmon occur in anything like the numbers which formerly prevailed in the East, though the species are entirely distinct and peculiar to the Pacific. The waters of California, Oregon, and British Columbia boast of the possession of several kinds, how many has not yet been ascertained, as the different ages and sexes of one have in many instances been described as two or more totally distinct species. One of the objects of the Fish Commission is to solve the problem in question, by securing specimens of all ages and of both sexes from all North American localities, and, by a critical investigation and comparison, to determine precisely the limitations and relationships of each kind. Material for this will, with suitable illustrations, it is hoped, be ready before long, which will be presented to Congress for publication if it should be called for.

The term salmon properly implies a fish of the genus *Salmo*, which spends a certain portion of its time in the ocean, and then runs up into the fresh waters to spawn. We know of no species of the genus which remains in the salt water permanently throughout the year; but there are many that continually abide in the fresh water, and of these North America has her fair share.

An important memoir on the genus *Salmo*, by Dr. Suckley, was prepared for the report on the northwest boundary survey. This, by permission of the State Department and Mr. Archibald Campbell, has been in charge of the Smithsonian Institution for many years, and will be found in the appendix of this report, (page 91.) Although many of the conclusions of Dr. Suckley are doubtless erroneous, yet the amount of information and critical inquiry exhibited in the paper is very great, and it will serve as an excellent basis for more correct memoirs hereafter. The species given by Dr. Suckley, arranged in certain indicated groups, are mentioned on page 92.

In consequence of the fact that the waters of the Sacramento Valley are much warmer than the ordinary salmon-streams of the United States, the fish from that locality would seem to be especially adapted to the more southern waters of the United States. Its precise species has not been determined, but Dr. Suckley identifies it with the Columbia River "quinnat," (*Salmo quinnat*, Rich.)

The experience of salmon-culturists in Europe goes to show that the *Salmo salar* will not thrive where the water is of a higher temperature than 60°, or at most 65°, during the summer-season. There are few of the rivers of the United States that do not reach a higher temperature than that, especially those from Cape Cod southward. Indeed, experiments prosecuted during the period of shad-hatching in the Connecticut and the Hudson show that the waters there exhibit a temperature of 80° as early as the 1st of July.

For this reason, probably, as far as our reliable information goes, the salmon in olden times did not occur west of the Connecticut, or at least of the Housatonic River, the assumption of its existence in the Hudson resting upon the statement of Hendrick Hudson, to the effect that he had captured salmon in nets at the mouth of the river in August. There is, however, no question, as suggested by Mr. J. C. Brevoort, but that reference was had by him to the weak-fish, (*Cynoscion regalis*,) which has much of the appearance of the salmon, and with its allied species is frequently called salmon, salmon-trout, &c.; the known habits of the salmon entirely precluding the idea that it could have been seen by Hudson under the circumstances mentioned.

In the Sacramento fish, however, we probably have a species which will answer the purpose on our eastern coast, as far south as the James, and it is proposed to devote the greater part of the supply of eggs received from Mr. Stone toward stocking the waters of the Hudson, the Delaware, the Susquehanna, the Potomac, the James, and possibly the streams still farther south which head in the Alleghanies. The Hudson, the Delaware, and the Susquehanna appear pre-eminently adapted to these fish, as the first dams occur at a considerable distance from their mouths, respectively, and arrangements will doubtless be made for suitable fish-ways before there is any probability of the return of the young salmon from the sea.

It is also proposed to try the experiment of introducing the Sacramento salmon into the waters on the southern side of the great lakes, where the temperature is comparatively high, and the conditions otherwise favorable for the western salmon.

Whether this fish will thrive in the Mississippi River, it is, of course, impossible to tell, although it is proposed to make the experiment in this case also. Salmon penetrate the Columbia, Frazer, and Yukon Rivers to a very great distance from their mouths, and it is not at all impossible that in the Mississippi, with the absence of any obstructions for a long distance, or of any current materially greater than the tides of the sea, the fish would make their way without experiencing the exhaustion which they manifest in the western waters, where they are obliged to surmount so many barriers. Fish are necessarily continually in motion, and this, when not requiring violent efforts, as in ascending dams, is not more exhausting in a river than in the ocean.

As far as the sojourn of the California salmon in the Gulf of Mex-

ico is concerned, it is quite probable that whatever the degree of heat to which they are subjected in the summer-season, they probably require during their residence in the sea a temperature as low, at least, as about 40° Fahrenheit; this inference being based upon the fact of their restriction to more northern latitudes, in which this temperature is most likely to be found. In considering the question of introducing the California or other salmon into the tributaries of the Mississippi, the inquiry was naturally suggested as to the temperatures of the Gulf of Mexico, into which the salmon would pass in their outward journey, and where they would probably remain.

Application for information was accordingly made to Captain Patterson, Superintendent of the Coast Survey, who kindly furnished copies of records from the archives of the office, (for details of these, see appendix,) from which we learn that in certain portions of the Gulf, where the surface-temperature was 77°, it was 50° at a depth of 230 fathoms, and at 420 to 790 fathoms it was noted at 35° and 36° Fahrenheit, in the month of April. At another locality, with a surface-temperature of 77½°, that at the bottom was 38°. At a depth of 1,133 fathoms, in a line from the mouth of the Mississippi to the Tortugas, latitude 27° 16′ and longitude 86° 57′, the temperature at the bottom was found to be 29°. On another line of soundings, between the mouth of the Mississippi and the Tortugas, a temperature of 34° was found at a depth of 896 fathoms; while between Cuba and Florida 38° were noted at 600 fathoms; and on a line from Mobile to Key West the temperature at 190 fathoms was found to be 38°, that at the surface being 83°.

Although it is probable that these indications, some of which were perhaps made by the old-fashioned thermometers, may be somewhat erroneous, yet there can be no question as to the occurrence in the Gulf of Mexico of very deep water and of temperatures perfectly suited to the abode of salmon of any species. Neither can there be any doubt of the occurrence of suitable food in this same region. Therefore there seems to be no reason to question that all the conditions needed for the growth of this fish are to be met with in the Gulf of Mexico; and at any rate we are warranted in making the experiment for the purpose of determining the fact.

5.—*The land-locked salmon* (*Salmo sebago?*).

Certain bodies of water in Maine, especially the upper lakes of the Saint Croix, Reed's Pond, near Ellsworth, Sebec River and Pond, and the Sebago Pond, are inhabited by a variety of the salmon in general habits and appearance closely resembling the true sea-salmon but differing in size. Their average weight in most of the localities mentioned is from 2 to 4 or 5 pounds, sometimes, however, being taken weighing from 10 to 15 pounds. The Sebago fish is, however, much larger; the mature fish averaging perhaps 6 to 8 pounds. A similar fish occurs also in the lakes of New Brunswick and perhaps of Nova Scotia.

Much ingenuity has been expended in the discussion of the question whether these are or are not the true salmon. They appear to present trifling peculiarities; but so far no difference of any special value has been noted. They take the fly with the utmost eagerness, and there is no fish that affords better sport, especially in localities where they abound. To Dr. A. C. Hamlin, of Bangor, we owe a very interesting article upon this fish, published in Lippincott's Magazine for May, 1869, and reproduced on page 338. This gentleman is of the opinion, after a careful investigation, that the variety is really of modern origin, having been developed only since the erection of mill-dams on the streams mentioned. He thinks he has evidence that forty or fifty years ago, or possibly one hundred, no such kind of fish was known in these streams, and that it was only after the erection of the dams, making the passage of fish from below impossible, when the young fish were penned into the upper waters and rendered averse to the experiment of going down over them, that the so-called land-locked salmon was met with. This conclusion is, however, stoutly contested by other authors, as by Dr. A. Leith Adams. The land-locked salmon, however, whether a distinct species or a variety of the true salmon, is one of very great value for stocking our small lakes; and another season it is proposed, should Congress authorize it, to attempt operations on a large scale in securing these eggs and placing the young fish in the more western waters.

The fish are taken readily with the fly throughout the greater part of the year, at least from early spring until late in the autumn, with the exception of a short interval in the hotter weather of midsummer.

Many persons maintain that the salmon of Lake Ontario is really land-locked; that is, it does not spend any portion of its life in the ocean. This, however, is a question which cannot be determined by our present data.

6.—*The sea-trout* (*Salmo immaculatus ?*).

Another fish which has been suggested for introduction into the waters of the United States is the sea-trout (*Salmo immaculatus ?*). This is very common in the waters of the Gulf of Saint Lawrence, and also in those of the Atlantic coast in Nova Scotia. It runs up in the spring into brackish waters in great numbers for the purpose of spawning. It is very abundant in Newfoundland and on the coast of Labrador, where immense numbers are caught and sent to the Boston market. As yet we know very little of its natural history; but there seems no reason to doubt that it would answer admirably for the streams on the coast of Maine. As a fresh fish it is of delicious flavor, although very inferior to the salmon when salted.

7.—*The lake-trout* (*Salmo namaycush ?*).

This fish, very characteristic of all the great lakes of the Northern States, and occurring in one variety or another in smaller bodies of water

all along our northern frontier, is variously called salmon-trout, lake-trout, togue, &c. The exact number of species, if actually more than one, yet remains to be determined. It is a valuable food-fish, and is especially prominent in this connection in Lakes Superior, Michigan, Erie and Ontario. As affording sport to the angler, it is far inferior to other members of the genus *Salmo*, but, from its size and ease of manipulation and transfer, has already attracted much consideration. It has for some years been the subject of attention on the part of the New York State commissioners and of their agent, Seth Green, who every autumn collects millions of eggs from the fisheries on the Canadian side of Lake Ontario to be hatched at Caledonia, N. Y., for distribution to the lakes in the interior of New York. The experiment has lately been made of planting the young fish in running water, as the Susquehanna, &c.; but it yet remains to be seen how they will thrive.

The lake-trout is eminently worthy the attention of States along the great lakes, since, with the white-fish, it constitutes by far the most important element in the great fisheries.

8.—*The hucho or Danube salmon*, (*Salmo hucho.*)

Another species which promises to be of value in the United States is *Salmo hucho*, or the salmon of the Danube. This fish has been warmly recommended as admirably suited for the Mississippi River, since, unlike the true salmon, it appears to spend most of its time in the river, seldom, if at all, making its way into the salt water. Opinions differ, however, in this respect, as to whether all the Danube fish spend a part of their life in the Black Sea, or whether it is those only which belong to its immediate vicinity that run into it. The hucho is of good quality for the table, and attains a weight of from forty to sixty pounds. It passes at the proper season into the smaller tributaries of the Danube, and is taken throughout its extent in immense numbers. It is a voracious fish, however, and feeds exclusively in the river, devouring other fishes with great avidity. In my judgment, it would be inexpedient to introduce this fish into waters where the true salmon live; the latter having the excellent quality of not disturbing the existing inhabitants of the rivers, but deriving the material of its growth, after the first few months of its existence, from the ocean. Unless the Sacramento salmon can be naturalized in the Mississippi, no other species but that of the Danube is likely to find suitable quarters there; and the question of its introduction will, therefore, be taken into consideration, after more full information in regard to the habits of the fish can be obtained. Further details respecting the hucho will be found in the article by Mr. R. Hessel on page 161.

9.—*Small American trout.*

I have already referred to the various questions connected with the propagation of the eastern brook-trout, (*Salmo fontinalis*,) and which, in view of the extent to which it is cared for by the States and by private

establishments, requires no attention on the part of the United States. A second eastern species, of great beauty, the blue-back, (*Salmo oquassa*, Girard,) is found in the lakes at the headwaters of the Androscoggin, Rangeley, Oquassoc, &c., where it inhabits their depths for the greater part of the year, only coming to notice for a few weeks in the autumn, when it enters the tributary streams or outlets to spawn. No proposition has yet been made to multiply this species artificially.

In this connection it may be remarked that, in the same lakes, the common brook-trout (*Salmo fontinalis*) occur of enormous size, even up to ten pounds, and that Mr. George Shepard Page, and his associates of the Oquassoc Angling Company, are about establishing a hatching-house for the purpose of securing eggs of this variety, known as the Rangeley.

There are many species of brook and pond trout in the Rocky Mountain and Pacific region of the United States, as well as in British North America; none of which, so far, have attracted the attention of fish-culturists on account of special merit.

10.—*The Sälbling*, (*Salmo salvelinus.*)

Another European fish that might be introduced to advantage is the char, or *Salmo salvelinus*. This is a species that lives, more or less, in the larger lakes, running up into tributary streams to spawn, and in this connection would serve an excellent purpose for stocking interior waters that have now no specially desirable inmates.

11.—*The grayling*, (*Thymallus tricolor.*)

A species of the salmon family found in restricted areas of the United States, has lately attracted much attention among fish-culturists and sportsmen. It seems to be prolific and numerous in favorable waters; is excellent as food, and what, to many, are more admirable qualities, will take the fly and make a spirited contest with the angler before he can land him on the shore or in his boat. It has also a most beautiful combination of colors on the body as well as on the very large dorsal fin that is a peculiar character in this genus.

The grayling has lately been brought extensively to notice as occurring in the waters of Michigan, and even in that State seems to be confined to certain spring-fed rivers in the lower peninsula. It is also found in the headwaters of the Missouri in the region adjacent to the valley of the Yellowstone. Whether it is different from the grayling found in certain rivers of Alaska, is a question not yet positively decided, but its separation as a species from the English and European *Thymallus vulgaris* Nilss. is marked and decided.

It has been successfully transported from Michigan to New York State by Fred. Mather and Seth Green, as also to Southern Michigan, for the purpose of introduction into trout-streams. Seth Green has succeeded in hatching the eggs, and has found them well adapted to the artificial processes.

12.—*The white-fish, Coregonus, etc.*

In the report by Mr. Milner, on page 1, will be found the result of his investigations, prosecuted through two seasons, with regard to this the most important fish of the great lakes; and in his general conclusions and recommendations, as to the future treatment of the subject, I entirely concur.

Few fishes of North America will better repay efforts for their multiplication than the white-fish. It is to this species especially that the States bordering on the great lakes have had their attention directed, and it is probable that the efforts of the United States will not be required to any great extent in aiding the multiplication of their numbers. It is understood that the newly-appointed commissioners of Michigan aim at introducing to the waters bordering on that State at least eight or ten millions of artificially-hatched eggs, and it is probable that Wisconsin, Ohio, and Minnesota will sooner or later follow suit. The introduction of this fish into the lakes of California and Utah will, however, continue to occupy my attention as far as the funds at my command will permit.

Otsego Lake in Central New York, the head of the Susquehanna River, is tenanted by a fish of the finest quality called the Otsego bass, (*Coregonus otsego*,) a true white-fish, and not yet satisfactorily distinguished from the *C. albus*, or the white-fish of the lakes. This is now the subject of experiment in the way of artificial multiplication for the benefit of Otsego Lake, and may hereafter furnish a valuable contribution to other lakes. Otsego Lake is, perhaps, the most southern station for the genus *Coregonus*, in the Eastern United States at least, and the fish from its waters are probably well adapted to other lakes of the same or even more southern latitudes. The experiment now making at Cooperstown, N. Y., under the direction of Capt. Elihu Phinney and Capt. P. P. Cooper, is, therefore, one in which the public have a great interest.

13.—*The nerfling, orfe, or golden tench.*—(*Idus melanotus.*)

A fish lately introduced into England from Germany is the "orfe" or "nerfling," *Idus melanotus*, a cyprinoid related to the European tench, and which is valuable for its beauty, color, and appearance, as well as for food.

It is said to surpass the gold-fish in the brilliant red color that covers the upper portion of the body. The belly portion is white. It is also said to be more active and lively in its movements, and attains a much larger size. It is very prolific, and sustains its numbers in larger bodies of water than the gold-fish does. Those who have seen this fish in its native waters state that there is no more brilliant sight imaginable than to witness the schools of "nerflings" rise in a body to the surface and flash along in the sunlight, as they delight to do.

The bright, red color of this beautiful fish is not found in the original wild species, but is a character developed in domestication, and perpetuated in the progeny by breeding in and in, or at any rate by selection of those individuals possessing the character in a superior degree. This process continued through many generations develops a tenacious tendency in all to reproduce the character, and a variety is established.

14.—*The carp.*

Sufficient attention has not been paid in the United States to the introduction of the European carp as a food-fish, and yet it is quite safe to say that there is no other species that promises so great a return in limited waters. It has the pre-eminent advantage over such fish as the black bass, trout, grayling, &c., that it is a vegetable feeder, and, although not disdaining animal matters, can thrive very well upon aquatic vegetation alone. On this account it can be kept in tanks, small ponds, &c., and a very much larger weight obtained, without expense, than in the case of the other kinds indicated.

It is on this account that its culture has been continued for centuries. It is also a mistake to compare the flesh with that of the ordinary *Cyprinidæ* of the United States, such as suckers, chubs, and the like, the flesh of the genuine carp (*Cyprinus carpio*) being firm, flaky, and in some varieties almost equal to the European trout.

Mr. Hessel imforms me that there is the greatest imaginable difference in the taste of the so-called carp in the European ponds, and that a species very closely allied to the carp (*Cyprinus carassius*) differs from it in the greater abundance of bones and its muddy flavor. What he considers as a hybrid between the two described as *C. kollari*, is in very many parts of Europe the representative of the carp, being frequently found in Germany, Holland, and Belgium under this name.

Among the estimable varieties of the true carp, Mr. Hessel specifies as the best the king-carp, or *Cyprinus rex cyprinorum*. This has the peculiarity of being almost destitute of scales, only a few being attached here and there to the skin. There are also, according to this eminent pisciculturist, varieties of carp in which the generative apparatus seems to be atrophied so as to render them incapable of reproduction. These are found in various regions on the Upper Rhine, on the Danube, on the Rhine, and the Po, and are very much sought after, bringing three times the price of other fish; indeed, as already remarked, they are considered equal to the trout. Mr. Hessel professes to be acquainted with a method of producing this sterility on a large scale and with certainty. Another race equally eligible is the one entirely destitute of scale, (*Cyprinus nudus*, vel *alepidotus*,) in which the skin is soft as the finest velvet, requiring no scaling, and when cooked adding greatly to the savor of the fish. The constant form of this only occurs in certain lakes in eastern Europe. Neither of these varieties is known in England.

The best carp, Mr. Hessel thinks, are to be found in the region of the Danube, characterized by the elevated, fleshy, and compressed back, a rapid growth, and delicious flesh. For almost thousands of years they have been kept in ponds connected with various public and private estates.

15.—*The gourami.*—(*Osphromenus olfax.*)

A fish that has attracted the attention of all interested in the introduction of valuable animals to the country of their residence is the gourami.

It has had an existence, whether indigenous or not, for many centuries in the fresh waters of Cochin China, and is found also in portions of the mainland and islands of the China Sea and Indian Ocean. It has been successfully acclimated in certain islands to the eastward of Africa. Living specimens are now in the possession of the Museum of Natural History and of Mr. Carbonnier, of Paris. Attempts have been made, without satisfactory success, to introduce it into regions of South America, the West Indies, Southern Africa, Australia, Egypt, and France.

The qualities that are brought forward as causing so high an estimate of the value of the *gourami* are its superior excellence as food and the fact that it is adapted to waters under a hot sun, attaining the highest degrees of temperature. It is also largely a vegetable eater, feeding upon water-plants of genera that are found in widely separated regions of the globe. It may be fed, too, with numerous articles of ordinary food, and the refuse of the table, and kept in confined bodies of water, provided they contain suitable plants.

It attains, under favorable circumstances, the weight of twenty-five or thirty pounds, though from three to five is said to be the average. It is also said to thrive in brackish as well as fresh waters.

The numerous failures to transport it and keep it alive during long voyages would scarcely influence American fish-culturists against its attempted introduction, as it is well known that inexperienced persons lose those fish during transportation which have the greatest tenacity of life under proper treatment. The fish could be brought from the Mauritius, India, Java, China, or other accessible localities, and, by care in selecting the period and route of the transfer, the experiment would doubtless be successful. Recent experiments have shown that some varieties resist the influence of cold more than others; a temperature even of 47° F. having been endured with impunity in the case of a number lately transported to France. They might be readily introduced from the region of China into the high-temperature "tule" lakes of Southern California and Nevada, and from there distributed farther east.

They guard their eggs and young with the utmost vigilance and courage, and their propagation and multiplication can be left to nature if the proper conditions in water and food are afforded them.

16.—*The sterlet.*

The sterlet, (*Acipenser ruthenus*,) a small species of sturgeon, found in Russia, has a superior reputation as a table-fish. The Russian minister of Crown lands has caused it to be introduced from its original home in the Volga to the vicinity of St. Petersburg.

As the embryo has so short a period in the egg stage, the transportation of the latter for long distances is attended with many difficulties. By means of a carefully-constructed apparatus, and provision for the anticipated hatching of the eggs *en route*, in 1870, a considerable number of the young fry were transported from Russia and introduced into the waters of Sutherlandshire, Scotland, in apparently good condition.

It has been, on several occasions, suggested that it would be a valuable acquisition to the United States for such waters as the Ohio and Mississippi Rivers, which are said to be very similar in their character and in their related climate to the Volga, of Russia, in which the species is native.

Quite recently a number of sterlet were brought from St. Petersburg to the Brighton aquarium, where they form a conspicuous feature. They were obtained in the Volga, and transported 1,400 miles in the well of a fishing-boat to St. Petersburg, and thence by steamer to London.

It is from the roe of the sterlet that caviare of the finest quality is made, which constitutes an article of commerce and trade in Russia; and of which, in late years, a limited quantity has been made in the United States from the lake and Atlantic coast sturgeons.

17.—*Hybrid fish.*

In certain establishments in Europe much attention is paid to the artificial production of crosses between certain closely-allied species of the Salmonid family, as the Salmon, the Brook-Trout, the Lake-Trout, the Säbbling, &c. The fish thus produced, though for the most part barren, and requiring a continuation of the operation in successive years, are of very superior quality, of tender flesh, and grow with great rapidity, as is usually the case with animals with deficient organs of generation. They, indeed, bear the same relations to other fishes of their kind, as do domestic cattle, hogs, chickens, &c., when altered to the perfect animal. Salmon thus hybridized lose the instinct of migration to the ocean. There is no reason why the same method may not be applied to other fresh-water species, and to certain sea-fish, with corresponding results.

CONCLUDING REMARKS.

It is perhaps hardly necessary to summarize here the steps taken to increase the supply of shad in the United States, as the subject has already been fully treated of.

As shown in the earlier part of the present report, my efforts, in 1872,

as United States Commissioner of Fish and Fisheries, so far as salmon were concerned, were directed to securing a large supply, first of *Salmo salar*, or the Atlantic salmon, from the establishment of Mr. Atkins, at Bucksport, and from the river Rhine, in Germany; and, second, of the California salmon (*Salmo quinnat?*) from the Sacramento River, through Mr. Livingston Stone, the details of which efforts it is unnecessary to repeat here.

In the accompanying report by Mr. Atkins (page 226) will be found the history of his experiments, with much practical information in regard to the habits and peculiarities of the fish. A similar article in reference to the California salmon, by Mr. Stone, is given on page 168.

The labors of 1873 will, it is hoped, be conducted on a much larger scale, and I trust that enough eggs of the Sacramento salmon may be procured to make a satisfactory beginning of the experiment. I am quite well satisfied that it is to this species that we are to look for a supply for such rivers as the Hudson, Delaware, Susquehanna, Potomac, James, and perhaps others still farther south, as well as for the waters of the Mississippi Valley. Eastern salmon, on the other hand, will perhaps be best adapted to the rivers of New England and to the great lakes; although it is proposed to introduce both kinds into such localities as the means at my command will permit. There is nothing to prevent the two species living together in the same stream, especially in view of the fact that it is only the young fry, for the first year or two, which require food in the fresh water, the great mass of the material of growth being derived from the sea. Their periods of migration, too, are entirely distinct; the western species entering the rivers early in winter, and spawning at the headwaters as early as August; while the eastern salmon, coming in several months later, does not spawn until October or the beginning of November. Should no change take place in the habits of either kind, the salmon-season would be very much longer than otherwise, and salmon could be had, perhaps, over a period of from eight to eleven months, instead of three or four, as at present.

The great advantage of the Sacramento fish is to be found in its ability to sustain itself in a much higher temperature than that endurable by the Atlantic-coast salmon. Thus, while the eastern is said to be driven back to sea, in Germany at least, by a temperature of 65°, (60° being the maximum of preference,) the Sacramento fish occupies a river flowing through one of the hottest regions of North America, where in the season of 1872 Mr. Stone found the prevailing temperature during the whole season of the salmon-spawning to be from 100° to 115° in the shade, and almost unendurable. It is true that the river-water at the United States hatching establishment is cooled by the melting ice and snow from Mount Shasta, but lower down the Sacramento, where the salmon formerly spawned in great numbers, and do still to some extent, the temperature in the river reached 75° F., and even more during the summer.

Another fact of importance connected with the Sacramento fish is the great rapidity of its growth, those of corresponding age being almost twice as heavy as their eastern relatives. According to Mr. Reeder, fish commissioner of Pennsylvania, the Sacramento salmon, which were introduced into the Susquehanna River in February, 1873, were found in good health and condition in the following September, measuring seven or eight inches in length, while the Penobscot salmon, about ten months old, were not half the size. This difference is appreciable in all stages of growth, the eggs and young fish being twice as large as those of the eastern species.

The Sacramento salmon is said to lack the very delicate flavor of the eastern fish. This, however, is stoutly denied, especially by Mr. Throckmorton, whose letter on the subject will be found on page 373.

In any event, the difference must be trifling when the fish is procurable fresh; and if the two species could be tasted side by side, under the same conditions, it is probable that the difference would prove to be of very little moment.

The supposed disinclination of the Sacramento fish to take the hook has been presented as a great objection to it. This, if well founded, would be of very little consequence, since salmon, for economical purposes, are more generally taken in nets than with the hook. But, according to Seth Green, they can be taken with the fly; and Mr. Livingston Stone maintains, as shown in his report, that they will bite voraciously at the roe of their own species, and can be taken in any number. The young fish in the hatching-ponds rise with the greatest readiness To Mr. Stone's report on this species I refer for further details.

As already remarked, experiments are contemplated in reference to the multiplication of the land-locked salmon and of the lake-trout. Whether the sea-trout, or white trout of the eastern coast, will be worth any special effort for its increase, is very doubtful. It is proposed, however, as soon as it can be accomplished, to secure some of the impregnated eggs of the Danube salmon, (*Salmo hucho*,) which appears especially fitted to the Mississippi River. The objection to this species, which attains the weight of fifty pounds and multiplies very rapidly, is mainly drawn from its alleged voracity, and from the fact that it is almost exclusively a river-fish, feeding therein all the year, and, of course, devouring other kinds in keeping up its own growth. At present, however, there are very few fish of any special value as food in the great system of waters of the Mississippi Valley; the black bass, the salmon-perch, or wall-eyed pike, (*Lucioperca*,) and, perhaps, one or two species of pickerel, being most important. Of the great variety of suckers, chubs, sun-fish, &c., but little commendatory can be said. The great bulk of these fish, however, and of nearly all the *Cyprinidæ*, are proverbial for their insipidity, and they are generally esteemed worthless as food. The effect of introducing the Danube salmon would be simply to substitute for a superfluity of fish of very inferior value, a kind having all

the gamesomeness and excellence of flesh of the salmon, and I think it would be perfectly safe to make the experiment. Under any circumstances, the Danube salmon is a less voracious fish than the pickerel, and might probably require much less weight of food to acquire a given amount of growth.

Some of the other species referred to above will probably be taken up for consideration at an early day.

The restoration of food-fishes to localities originally tenanted by them, or their transfer to new waters, is, however, a question of time; and in the immense extent of our river and lake systems, many years must necessarily elapse before the work can be accomplished. It is also inexpedient to attempt to cover too much ground at once, as in the necessary limitations furnished by the amount of the appropriations, and the difficulty of finding skilled assistants, it is considered the better policy to render fish very abundant in a few centers by concentrating effort upon them, and then from these centers to carry on the work elsewhere. It is not a percentage so much as an absolute number of young fry that must be sacrificed to the rapacity of the pre-existing inhabitants of the stream into which they are introduced; and it is evident that, supposing that the average probability of destruction amounts to 10,000 fish in a given period, if we introduce only that number there will be no surplus; whereas with 50,000 the excess will be enough to allow the maturing of adults sufficient to stock the waters.

It must, however, be borne in mind that it is not sufficient to take measures for introducing the fish, whether young or adult, into new waters, but that much then remains in the way of protecting them when once established, and in securing their passage to and from the sea. State legislation will be required to bring about the removal of obstructions; introduction of suitable fish-ways; prevention of the pollution of the waters, and the capture of the fish at improper times, by improper modes, &c.

When we consider that the prime cause of the decrease in our salmon and shad fisheries is believed to be in the erection of impassable dams, thus preventing their access to the spawning-grounds, it will be readily understood that, unless some provision be made for surmounting these obstructions, the fisheries cannot be self-sustaining. Fortunately, however, in the fish-ways, of which a great variety has lately been devised, we have in most cases a practical remedy; experience having shown that where these are inserted in dams, with the lower end perfectly accessible to the fish and a sufficient volume of water issuing from it, fish will ascend with great facility. This is especially the case with the salmon and alewife, but it is also probably true of the shad. The general theory of fish-ways, and the various forms suggested, or in use, will be found given in detail in an admirable essay on the subject in the present report as prepared by Mr. Atkins.

Care must also be taken, in planting the fish, to introduce them as far

up the stream as practicable, since it is an established fact that adult fish will always return to the place where they first made acquaintance with the water, passing directly by the mouths of streams or tributaries better adapted to their purposes, to gain their orignal home. For this reason, it is well to carry the young fish to the highest point in a stream that can be reached, even though numerous fish-ways may be required to permit the return of the adult fish. It may safely be assumed that fish born below an impassable dam will not ascend far above it, even with a suitable fish-way; although it is quite possible that when they feel themselves in a powerful current of the fish-way, they may enter it and reach the uppper part of the dam. Here, the water being quiet, they will probably remain without proceeding to any considerable distance. Mr. Seth Green informs me that the fish hatched at Castleton, below Albany, when ascending the river as adult fish, very rarely go beyond their original starting-point, so that, while there is a great supply at that locality, there has been little or no increase in the numbers higher up the river.

In addition to the construction of fish-ways, steps must be taken to prevent the capture of the breeding-fish in improper numbers. This can only be done satisfactorily by providing for a close time during the fishing-season of two or three days in each week, during which no fish are to be taken, and by stopping the fishery entirely after a certain date. This period will vary with the season; the time of cessation, as far as shad are concerned, coming earlier in the South than in the North—perhaps about the middle of May for the Potomac River, the first of June for the Delaware and Susquehanna, the middle of June for the Hudson, and the twenty-fifth of June for the Connecticut. A proper close time for the eastern salmon would fall some time in August or the beginning of September.

The use of nets and other engines for the capture of adult fish can only be considered improper when carried to an excess, and covering too great a period of time. Anything, however, that affects the young and destroys them before attaining their full growth should be prohibited. Among the most injurious agencies in this direction are the fish-dams, so abundant in certain streams in the autumn, consisting of two walls of stone in the shape of the letter V, the angle pointing down the current, and opening into what is called a fish-basket. The object of this is to guide the descending fish, in the entire breadth of the river, into this basket, into which they fall, and from which they are sometimes removed by the wagon-load. The special object of this kind of fishery is the capture of eels, which, as is well known, run down, when mature, in the autumn to the sea for the purpose of spawning; but the baskets take millions of other fish, and are especially injurious to the young shad. Pennsylvania and Delaware have, we believe, prohibited the use of these dams in shad-streams, and with very great propriety.

Other points to be regulated, and requiring more or less of legislative

interference, are the introduction of injurious chemicals, refuse of gas-works, sewage, and other substances, into the rivers, by means of which the fish, both adult and young, are poisoned, or else their passage through to their proper spawning-grounds prevented, to say nothing of the unpleasant taste imparted to the fish themselves when exposed to these influences. These and other improper interferences with the fish and the rights of the people at large, which will readily suggest themselves, should, as already stated, invoke the legislation of the States; and, unless these can be guaranteed, it is hardly worth while to attempt the planting and propagation of fish in American rivers.

It is true that by continuing indefinitely the practice of artificial impregnation of the eggs and introduction of the young into the water, the supply of fish can be maintained; and should they, in ascending the streams, find an impassable barrier, the only effect would be to furnish a great abundance to the fishermen below the obstruction, while those above it would be entirely cut off. It is not to be expected, however, that either State governments or Congress will continue to make such appropriations indefinitely, and it is quite time that a general system of legislation should be devised and carried into effect by the various States.

In concluding the present report, I have much pleasure in returning my special acknowledgments to the commissioners of Maine, Massachusetts, Connecticut, and New York for their hearty co-operation in the steps taken to carry out the law of Congress in reference to the multiplication of the food-fishes.

Salmon-hatching operations in the

Under whose auspices.	Place where spawn was collected.	Place where eggs were hatched.	In charge of hatching.	Waters stocked.
Maine	Newcastle, Ont	Whiting, Me	W. S. Peavey	Cobscook River
	do	Alna, Me	David C. Pottle	Sheepscot River
	Miramichi River, N. B.	Augusta, Me		Kennebec River
	Penobscot River, Orland, Me.	Norway, Me	Crockett & Holmes	Androscoggin Riv.
	Penobscot River, Bucksport, Me.	Bucksport, Me	Charles G. Atkins.	Penobscot River. Saint Croix River. Androscoggin Riv.
New Hampshire	Miramichi River, N. B.	Woodstock, N. H.	W. W. Fletcher	Merrimac River
	do	Concord, N. H.	do	do
	do	Meredith, N. H	Robinson & Hoyt	do
	do	do	do	do
	Penobscot River, Bucksport, Me.			do
	do			do
	do		W. W. Fletcher	do
Vermont	Miramichi River, N. B.	Charlestown, N. H.	Livingston Stone	Lake Champlain
	do	do	do	Connecticut River.
	do	Chester, Vt	A. D. Hager	do
	do	do	do	do
	Penobscot River, Bucksport, Me.	Rochester, N. Y	Seth Green	Lake Champlain
Massachusetts	Miramichi River, N. B.	East Wareham, Mass.	S. T. Tisdale	
	do	West Barnstable, Mass.	Dexter, Coolidge, & Bacon.	Stream on Cape Cod.
	do	Winchester, Mass	E. A. Brackett	Mystic River
	Penobscot River, Orland, Me.	do	do	Stream on Cape Cod.
	do	do	do	Merrimac River
	Penobscot River, Bucksport, Me.	do	do	do
	do	do	do	Mystic River
	do	do	do	Red Brook
Rhode Island	Newcastle, Ont	Poneganset, R. I		Pawtuxet River
	Penobscot River, Bucksport, Me.	do	J. H. Barden	Blackstone River
			do	Pawtucket River
			do	Pawcatuck River
Connecticut	Miramichi River, N. B.	Charlestown, N. H	Livingston Stone	Great Brook
	do	do	do	do
	do	Poquonnock, Conn	Poquonnock Company.	Quinnebaug River.
	Newcastle, Ont	do	do	Housatonic River.
	do	do	do	Farmington River.
	do	do	do	Quinnebaug River.
	do	do	do	Saugatuck River
	do	North Branford, Conn.	Waltonian Hatching Society.	Farm River
	do	Middletown, Conn.	Robert G. Pike	Connecticut River.
	Penobscot River, Orland, Me.	Poquonnock, Conn	Poquonnock Company.	Quinnebaug River.
	do	do	William Clift *b*	Great Brook
	Penobscot River, Bucksport, Me.	do	do	Saugatuck River
		North Branford, Conn.	Waltonian Hatching Society.	Southport River
	do	Westport, Conn		Connecticut River.
	do	do	do	Mystic River
	do	do	do	Thames River
	do	do	do	Housatonic River.
	do	do	do	Stream at North Branford.
	Penobscot River, Bucksport, Me.	Poquonnock, Conn	William Clift *b*	Great Brook

a Doubtful. The distribution was proposed in 1872, and no subsequent references made.

United States between 1866 *and* 1872.

Tributaries in which fish were placed.	Name of nearest city or village.	Number furnished by United States Commis'n of Fish and Fisheries.	Date of planting.	Total number of fishes.	References.
....	....	....	1870	225	Atkins's Report, p. 232.
....	....	....	1871	1,500	Fourth Report Commission of Fisheries, Maine, 1870, p. 28.
....	....	....	1871	800	Sixth Report Commission of Fisheries, Maine, 1872, p. 15.
Little Androscoggin River.	....	....	1872	21,000	Do.
Tributaries	....	50,585	1873	67,000	Atkins's Report, Table XI, p. 288.
....	....	77,550	1873	10,000	Do.
Tributaries	....	98,150	1873	130,000	Do.
Pemigewasset River.	Woodstock, N. H.	....	1866	15,000	Report Commission of Fisheries, New Hampshire, 1869, p. 6.
....	....	....	1867	250	Do.
Pemigewasset River.	Livermore Falls, N. H.	....	1869	5,000	
......do	....	....	1870	1,000	Report Commission of Fisheries, New Hampshire, 1871, p. 6.
....	Woodstock, Thornton, N. H.	....	1872	16,000	Report Commission of Fisheries, New Hampshire, 1873, p. 4.
....	....do	....	1873	160,000	Do.
Tributaries	....	14,000	1873	14,000	Atkins's Report, Table XI, p. 288.
Winooski River	Montpelier, Vt. ...	......	1869	2,500	Report Fish Commission of Vermont, 1869, p. 11.
West River	Weston, Vt.				
......do	....	......	1870	30,000	Report Fish Commission of Vermont, 1871–'72, p. 5.
Williams River	Bellows Falls, Vt.				
Winooski and Lamoille Rivers.	....	7,000	1873	7,000	Atkins's Report, Table XI, p. 288.
Agawam River (?)	....	....	1870	3,000	Massachusetts Report, 1871, pp. 11, 12.
....	....	....	1870	1,500	Do.
....	....	....	1870	700	Do.
....	....	....	1872	5,000	Massachusetts Report, 1873, p. 16.
Pemigewasset River.	Plymouth, N. H. ..	....	1872	16,000	Do.
....	....	21,450	1873	165,000	Atkins's Report, Table XI, p. 288.
....	....	1,430	1873	11,000	Do.
....	....	1,430	1873	11,000	Do.
....	....	....	1872	9,000	Third Annual Report Rhode Island, p. 4.
....	....	6,400	1873	64,000	Atkins's Report, Table XI, p. 288.
Tributary to Long Island Sound.	New London, Conn	....	1870	2,000	Atkins's Report, p. 230.
......do	....do	....	1871	90	Do.
Broad Brook	....	....	1871	1,876	Connecticut Report, 1871, p. 20.
Tributaries	....	....	1871	8,000	Connecticut Report, 1872, p. 28.
......do	Westport, Conn...	....	1872	*a*7,377	Connecticut Report, 1872, pp. 27, 28.
....	North Branford, Conn.	....	1872	*a*900	
Little River	Middletown, Conn.	....	1872	*a*600	
Tributaries	....	....	1872	17,000	Connecticut Report, 1872, p. 28.
....	....	....	1872	5,000	Atkins's Report, p. 241.
....	....	1,365	1873	4,500	Atkins's Report, Table XI, p. 288.
....	....	1,365	1873	4,500	Do.
Tributaries	....	34,880	1873	115,000	Do.
....	....	1,500	1873	5,000	Do.
Tributaries	....	3,000	1873	10,000	Do.
....	....	21,200	1873	70,000	Do.
....	North Branford, Conn.	10,100	1873	35,000	Do.
....	....	....	1873	43,000	Do.

b Private enterprise.

Salmon-hatching operations in the United

Under whose auspices.	Place where spawn was collected.	Place where eggs were hatched.	In charge of hatching.	Waters stocked.
New York	Penobscot River, Bucksport, Me.	Caledonia Springs, N. Y.	Seth Green	Hudson River
	do	do	do	Lake Ontario
	do	do	do	do
New Jersey	do	Bloomsbury, N. J.	J. H. Slack, M. D.	Long Island Sound
	do	do	do	Raritan River
	do	do	do	Delaware River
Pennsylvania	Newcastle, Ont	Dutchess Co., N.Y.		do
	do	Easton, Pa	Thaddeus Norris	do
	Penobscot River, Bucksport, Me.	do	do	do
Ohio	do	Castalia, Ohio	John Hoyt	Lake Erie
Michigan	do	Clarkston, Mich	Nelson W. Clark	Lake Saint Clair
	do	do	do	Lake Erie
	do	do	do	do
	do	do	do	do
	do	do	do	do
	do	do	do	do
	do	do	do	
	do	do	do	
	do	do	do	
	do	do	do	Lake Michigan
	do	do	do	do
	do	do	do	do
	do	do	do	do
	do	do	do	do
	do	do	do	do
	do	do	do	do
	do	do	do	do
	do	do	do	Lake Huron
Wisconsin	do	Waterville, Wis	H. F. Dousman	Lake Michigan
	do	do	do	do
	do	do	do	do
Total				

States between 1866 *and* 1872—Continued.

Tributaries in which fish were placed.	Name of nearest city or village.	Number furnished by United States Commis'n of Fish and Fisheries.	Date of planting.	Total number of fishes.	References.
Peating and Inglesby Creeks.	....	30, 000	1873	30, 000	Letter from Seth Green.
Salmon River........	....	15, 000	1873	15, 000	Do.
Oswego River........	....	15, 000	1873	15, 000	Do.
Small tributaries.....	....	2, 500	1873	2, 500	Do.
Headwaters..........	....	15, 000	1873	15, 000	Do.
Musconetcong Creek.	....	18, 000	1873	18, 000	Do.
Bushkill River.......	....	....	1871	2. 500	Pennsylvania Report, 1873, p. 15.
......do	....	....	1872	11, 000	Pennsylvania Report, 1873, p. 16.
Heitzman Spring Brook.	....	25, 000	1873	25, 000	
Castalia Spr'g stream.	....	2, 500	1873	2, 500	Atkins's Report, p. 288.
Lord's Lake	Pontiac, Mich......	....	1873	400	Information from N. W. Clark.
Orchard Lake........	Oakland Co., Mich.	....	1873	500	Do.
Walled Lake	....do	....	1873	500	Do.
Whitmore Lake......	Washtenaw Co., Mich.	....	1873	500	Do.
Gun Lake............	Hillsdale Co., Mich	....	1873	500	Do.
Barrier Lake	....do	....	1873	500	Do.
Diamond Lake.......	....	....	1873	1, 000	Do.
Barren Lake.........	....	....	1873	500	Do.
Lake near Marshall..	Calhoun Co., Mich.	....	1873	500	Do.
Headwaters St. Joseph River.	Hillsdale Co., Mich	....	1873	500	Do.
North Branch St. Joseph River.	....	....	1873	1, 000	Do.
......do	....	....	1873	1, 000	Do.
Stream tributary to St. Joseph River.	St. Joseph, Mich..	....	1873	1, 500	Do.
Headwaters Kalamazoo River.	Jackson Co., Mich.	....	1873	500	Do.
Grand River..........	....do	....	1873	500	Do.
Muskegon River.....	....	....	1873	1, 500	Do.
Manistee River	....	....	1873	1, 500	Do.
Ausable River	Roscommon Co., Mich.	....	1873	2, 000	Do.
Menomonee River ...	....	....	1873	7, 000	Letter of H. F. Dousman.
Oconomowoc Lake...	Oconomowoc, Wis.	....	1873	1, 000	Do.
Milwaukee River	Wauwatosa, Wis..	33, 900	1873	11, 000	Do.
....	....	517, 805	......	1, 258, 841	

Table of the distribution of young shad

By whom conducted.	Shad-hatching stations where young shad were procured.	Waters stocked with shad.
United States Commission of Fish and Fisheries.	Coeymans, N. Y., Hudson River	Alleghany River
Do	do	Mississippi River
Do	South Hadley Falls, Mass., Connecticut River.	Alleghany River
Do	do	Cuyahoga River
Do	do	White River
Do	do	Missouri River
Do	do	Platte River
Do	Washington, D. C., Potomac River	Greenbrier River
Do	do	New River
Do	Coeymans, N. Y., Hudson River	Calumet River
Do	do	Fox River
Do	do	Ashtabula River
Do	Lambertsville, N. J., Delaware River	Monongahela River
Do	Coeymans, N. Y., Hudson River	Wabash River
Do	do	Jordan River
Do	do	Sacramento River
Do	South Hadley Falls, Mass, Connecticut River.	Winooski River
Do	do	Housatonic River
Do	do	Penobscot River
Do	do	Otter Creek
Do	do	Detroit River
Do	do	Grand River
New Hampshire Commission of Fisheries.	North Andover, Mass., Merrimac River	Lake Winnepiseogee
Do	do	do
Do	do	do
Do	do	do
Vermont Commission of Fisheries.	South Hadley Falls, Mass., Connecticut River.	(Not recorded)
Do	do	Merrimac River
Do	Coeymans, N. Y., Hudson River	Lake Champlain
Massachusetts Commission of Fisheries.	South Hadley Falls, Mass., Connecticut River.	Whitney's Pond
Do	North Andover, Mass., Merrimac River	Mystic River
Do	do	Ipswich River
Do	do	Concord River
Do	do	Weweantit River
Do	do	Eel River
Do	do	Newmasket River
Do	do	Mystic River
Do	do	do
Do	South Hadley Falls, Mass., Connecticut River.	do
Rhode Island Commission of Fisheries.	do	Blackstone River
Do	do	Pawtuxet River
Do	do	Pawcatuck River
Connecticut Fish Commission	do	Poquonnock River
Do	do	Saugatuck River
Do	do	do
New York Commission of Fisheries.	Coeymans, N. Y., Hudson River	Genesee River
Do	do	do
Do	do	Lake Champlain
Do	do	Mohawk River
Do	do	Genesee River
Do	do	Lake Onondaga
Do	do	Canandaigua Lake
Do	do	Cayuga Lake
Do	do	Genesee River

(*a*) A few fry.

to the waters of the United States.

Name of city or village.	Date of planting.	Number of shad when starting.	Number of shad at destination.	Time young shad remained in the cans.	In charge of transfer.
Salamanca, N. Y	June 30, 1872	25, 000	25, 000	Ab't 7 h. 30 m.	Jonathan Mason.
Saint Paul, Minn	July 5, 1872	25, 000	25, 000	Ab't 60 h.	J. Mason & Chester Green.
Salamanca, N. Y	July 3, 1872	2, 000, 000	400, 000	24 h. 30 m.	Rev. William Clift.
Kent, Ohio	July 3, 1872		(a)	35 h. 15 m.	Do.
Indianapolis, Ind	July 4, 1872		400, 000	48 h.	Do.
Washington and Herman, Mo.	July 5, 1872		(a)	78 h. 25 m.	Do.
Denver, Colo	July 7, 1872		2, 000	124 h. 30 m.	Do.
Ronceverte, W. Va	June 6, 1873	50, 000	30, 000	15 h. 15 m.	James W. Milner.
Central Station, Va	June 10, 1873	40, 000	40, 000	25 h. 30 m.	H. W. Welsher.
South Chicago, Ill	June 16, 1873	70, 000	70, 000	38 h.	James W. Milner and J. Mason.
Appleton, Wis	June 20, 1873	70, 000	70, 000	62 h.	Do.
Ashtabula, Ohio	June 24, 1873	50, 000	50, 000	25 h.	Jonathan Mason.
Greensburgh, Pa	June 25, 1873	15, 000	15, 000	15 h.	J. H. Slack, M. D.
Logansport, Ind	June 30, 1873	40, 000	40, 000	40 h.	James W. Milner and J. Mason.
Jordan, Utah	June 30, 1873	40, 000	5, 000	Ab't 121 h.	Livingston Stone and H. W. Welsher.
Tehama, Cal	July 2, 1873		35, 000	170 h. 30 m.	Do.
Burlington, Vt	July 5, 1873	100, 000	100, 000	15 h.	James W. Milner and J. Mason.
New Milford, Conn	July 8, 1873	90, 000	90, 000	5 h.	Do.
Mattawaumkeag, Me	July 12, 1873	100, 000	100, 000	28 h.	Do.
Vergennes, Vt	July 20, 1873	100, 000	100, 000	12 h.	Do.
Detroit, Mich	July 24, 1873	100, 000	20, 000	44 h.	Do.
Ionia, Mich	July 24, 1873		80, 000	53 h. 30 m.	Do.
	1868		(b)		
	1869		400, 000		William W. Fletcher, M. D., and W. A. Sanborn.
	1870		(c)		
	1872		(d)		
	1867		(e)		Albert D. Hager and Chas. Barrett.
Concord, Vt	1867		(f)		Wm. W. Fletcher, M. D.
Burlington, Vt	1872		50, 000		
———, Mass	1867		5, 000		
Winchester, Mass	1868		(b)		
	1869		100, 000		
			180, 000		
			100, 000		
			100, 000		
			100, 000		
Winchester, Mass			1, 125, 000		
	1870		(c)		
———, Mass	1872		(g)		
}	1872		750, 000		Robert Holmes.
Mystic, Conn	1871		1, 500, 000		Rev. William Clift.
Westport, Conn	1871	5, 000, 000	(h)		E. M. Lees.
......do	1872	(g)			Do.
Rochester, N. Y	June 30, 1870		(i)	Ab't 10 h.	
......do	June 8, 1871		15, 000	Ab't 10 h.	
Whitehall, N. Y	June —, 1871		50, 000	Ab't 4 h. 30 m.	
———, N. Y	June 18, 1872		150, 000		
Rochester, N. Y	June 21, 1872		60, 000	Ab't 10 h.	
Syracuse, N. Y	June 25, 1872		30, 000	Ab't 6 h.	
Canandaigua, N. Y	June 12, 1873		54, 000	Ab't 10 h.	Oren Chase.
	June 16, 1873		54, 000	Ab't 9 h.	Do.
Rochester, N. Y	June 19, 1873		70, 000	Ab't 10 h.	Monroe A. Green.

(*b*) A certain amount of spawn.
(*c*) Some spawn.
(*d*) Several thousands of eggs.
(*e*) A few in a bottle.
(*f*) Several millions. (?)
(*g*) A few thousands.
(*h*) Not on record.
(*i*) A few shad.

Table of the distribution of young shad

By whom conducted.	Shad-hatching stations where young shad were procured.	Waters stocked with shad.
Michigan Commission of Fisheries.	Washington, D. C., Potomac River	Potomac River (*a*)
Do	Coeymans, N. Y., Hudson River	Grand River
Do	do	Raisin River
Do	do	Grand River
California Commission of Fisheries.	do	Lake Erie
Do	do	do
Do	do	Lake Michigan
Do	do	Bear River
Do	do	Sacramento River

(*a*) Destined for Grand River, Michigan. Finding that they were dying rapidly, the remaining living ones were put into the Potomac River. A trip of forty hours is too long for one man to attempt to carry shad successfully.

to the waters of the United States—Continued.

Name of city or village.	Date of planting.	Number of shad when starting.	Number of shad at destination.	Time young shad remained in the cans.	In charge of transfer.
Cumberland, Md	June 5, 1873	50, 000	10, 000	Ab't 9 h.	N. W. Clark.
Lansing, Mich.........	June 17, 1873	80, 000	80, 000	Ab't 45 h.	N. W. Clark and George Clark.
Monroe, Mich	June 28, 1873	....	50, 000	Ab't 44 h.	George H. Jerome and Oren Chase.
Lansing, Mich.........	June 28, 1873	....			
Cleveland, Ohio.......	June 20, 1871	12, 000	200	25 h. 45 m.	Seth Green.
Toledo, Ohio...........	June 20, 1871		(b)	....	
Chicago, Ill............	June 21, 1871		200	51 h.	
Ogden, Utah...........	June 23, 1871		200	104 h.	
Tehama, Cal...........	June 26, 1871		10, 000	184 h.	

(b) Not stated.

Table of shad-hatching operations in the United States.

By whom conducted.	Year.	Place of operation.	River.	Superintendent.	Beginning.	Ending.	Average temperature of water.		Shad taken.	Males.	Females.	Ripe females.	Number of eggs.	Young shad released.	Young shad sent to distant waters.
							Morning.	Evening.							
United States Commission of Fish and Fisheries.	1873	Augusta, Ga.	Savannah	Seth Green	Apr. 21	Apr. 28			13			(*)			
		New Berne, N. C.	Neuse	do	May 1	May 14	64.6	65.6	57			2	50,000	43,000	
		Weldon, N. C	Roanoke	do	May 15	May 29						(*)			
		Washington, D. C.	Potomac	James W. Milner	May 17	June 10	68.2	71.9	3,605			111	2,170,000	1,370,000	140,000
		Lambertsville, N. J	Delaware	J. H. Slack	June 10	June 30	73.2	78	169			29	495,000	433,000	15,000
		Topsham, Me.	Androscog'in	James W. Milner	July 14	July 16			16			(*)			
Maine Commission of Fisheries.	1868	Augusta, Me	Kennebec	N. W. Foster and Chas. G. Atkins.	June 28	July 4	70	75					100,000	50,000	
	1873	Bowdoinham, Me		Henry O. Stanley	June 15									100,000	
Massachusetts Commission of Fisheries.	1867	South Hadley Falls, Mass.	Connecticut	Seth Green	July 1	July 21								40,000,000	5,000, and "several millions."
	1868	do	do	do	June 20	July 16								60,000,000	
	1868	North Andover, Mass.	Merrimac	A. C. Hardy	June 24	July 15								Not recor'd.	"A certain amount of spawn."
		Winchester, Mass.	Mystic											"A large No."	
	1869	North Andover, Mass.	Merrimac	J. M. Gage	June 1	July 11	65.8	68.2	1,442				2,570,000	"A large No."	
		do	do	A. C. Hardy	June 10	July 27	(†)		1,590	1,105	567		2,160,000		2,105,000
	1870	do	do	do	June 1	July 19	69.8	74.4	934	401	533		1,861,000		"Some spawn."
	1871	do	do	do	May 20	July 22		68	4,289	3,053	1,236		4,530,000		
	1872	do	do	do	June 2	June 24		70	2,447	1,479	968		5,825,000		"Several thousand eggs."
Connecticut Commission of Fisheries.	1870	South Hadley Falls, Mass.	Connecticut	James Rankin	June 16	July 7	66.7	75.3					54,620,000		
	1871	do	do	Charles C. Smith	June 15	July 14	70.5	73	4,783	2,421	2,362		63,177,000		6,500,000
	1872	do	do	do	June 24	July 22	77.6	79.2	3,598	946	2,652		92,065,000		2,750,000, ("and a few thousand.")
	1873	do	do	do	June 23	July 28			3,013	1,051	1,962		44,556,000		
New York Commission of Fisheries.	1868	Coeymans, N. Y	Hudson	Seth Green	June 18			77						"Sev'l mil'ns"	
	1869	do	do	do	June 1	July 13								15,000,000	
	1870	do	do	do	May 25	July 7		76.5	1,354			110	2,604,000		"A few shad."
	1871	do	do	do	May 18	July 5	72.9	75.3	3,758			480	8,620,000	8,059,600	127,000
	1872	do	do	do	May 17	July 2	66.4	69.5	4,527			439	8,750,000	6,177,000	290,000
	1873	do	do	do	May 20	June 30	67.3	70.6	1,643			293	5,740,000	4,503,000	658,000
Pennsylvania Commission of Fisheries.	1873	Newport, Pa.	Juniata	Edward Boehme	May 10	June 15			(‡)			43	1,500,000		20,000
		Marietta, Pa.		H. W. Welsher										500,000	

* None. † Water at noon, 67°.9. ‡ Over 1,000.

CONTENTS.

APPENDIX A.

THE FISHERIES OF THE GREAT LAKES,

AND THE

(SPECIES OF COREGONUS OR WHITE FISH.)

I.—REPORT ON THE FISHERIES OF THE GREAT LAKES; THE RESULT OF INQUIRIES PROSECUTED IN 1871 AND 1872.

By James W. Milner.

A—INTRODUCTORY REMARKS.

1.—OUTLINE OF OPERATIONS.

In carrying out the work allotted to me in the region of the great lakes, in 1871, I made a tour of the entire shore of Lake Michigan and the islands, visiting nearly every fishing locality, gathering testimony of the fishermen as to the present condition of the fisheries, its comparison with former years, the kinds of nets in use and their effect on the numbers of the fish, and the opinion of the net-owners as to the influence of protective legislation. The visit to the fishing-grounds afforded opportunities for acquiring information in the modes of fishing, the species captured, and some knowledge of their habits, of which I availed myself as far as I could. A collection was made, embracing nearly all the species of the lake, which was, unfortunately, lost with the building of the Academy of Sciences in the great fire of that year in Chicago.

On being notified by you that the revenue-steamer Johnson would afford facilities for dredging, I went on board with a dredging outfit in September, after returning from the north shore of the lake, and remained with the steamer during a cruise of two weeks, dredging whenever it was possible, though the stormy weather during the trip prevented as extensive work as was desirable. Enough was done, however, to obtain a knowledge of the general distribution of invertebrate forms throughout all depths, and a collection of crustaceans, mollusks, and insect larvæ secured, which met the same fate as the collection of fishes in the fire. The late Dr. Stimpson had previously identified most of the species as the same as those of his own collection on a dredging expedition in 1870. The general distribution of white-fish food throughout the lake, bottom was sufficiently established.

In 1872 localities on Lake Superior were visited, a collection of the fishes obtained, and ample notes of their habits recorded. The fisheries of Detroit River and a portion of Lake Erie were examined, and information gathered with reference to fishing-interests, and specimens of the fishes preserved. From Detroit River a quantity of white-fish spawn was obtained and impregnated and placed in the troughs of Mr. N. W. Clark's hatching-house at Clarkston, Mich., with which gentleman a contract

was made for their care until ready to be turned into the waters. Arrangements were also made with Mr. N. W. Clark, and Mr. H. F. Dousman, of Waterville, Wis., for the care of the salmon-eggs furnished for the States of Michigan and Wisconsin.

A correspondence was opened with gentlemen of Wisconsin, who used their influence in obtaining a sufficient appropriation from the State for the expenses attending the introduction of salmon into its waters. Dr. J. W. Hoyt, Dr. I. A. Lapham, Hon. L. J. Farwell, and Mr. H. F. Dousman cordially assisted the movement and obtained the required aid.

During the legislative session of Michigan, by invitation from those interested, I visited the capital, and afforded such information as had been obtained with reference to the fisheries, and at the request of the chairman of the house committee drew up a bill for the appointment of commissioners of fisheries for the State. During the session an appropriation of $15,000 was made to defray expenses of propagating food-fishes in order to increase their numbers.

An attempt was made to interest all the States bordering on the lakes in the matter of protecting the fisheries, most of them having had the subject presented in some form previously. Letters addressed to the Governors were referred to the proper committees in the legislatures. In Ohio and Indiana the question came up in one form or another during the winter session. Illinois, though possessing a small extent of lake-coast, and having a large interest in the fish-sales of the Chicago market, has not yet taken the matter into special consideration.

The fish-dealers of the lakes were addressed, either in person or by letter, and as full statistics of the catch of 1872 obtained as possible, in order that the importance of the interest might be better understood.

2.—ACKNOWLEDGMENTS OF ASSISTANCE RENDERED.

I desire to refer to Mr. William D. Palmer, of Chicago, and Capt. Samuel Clement, of Waukegan, Ill.; Capt. E. Butlin and Mr. William Wright, of the Goodrich steamer-line; Dr. I. A. Lapham, of Milwaukee, and Mr. H. F. Dousman, of Waterville, Wis.; Mr. George Clark, of Ecorse, Mr. J. P. Clark, of Detroit, and Mr. N. W. Clark, of Clarkston, Mich., for various assistances and traveling-passes, materially lessening the expenses of the work; to Mr. E. W. Blatchford, of Chicago, Ill., for the use of instruments for deep-sea work and a complete set of nets; to Capt. David Evans and his officers, of the revenue-marine service, for their cordial assistance during the dredging-trip; to Mr. J. L. Ingalls, of Waukegan, Ill., for valuable aid in obtaining information through a long extent of shore that would otherwise have required a personal visit; and to many others who afforded information and support to this work.

In the following pages will be found the statistics of the catch of one year, conclusions with reference to the decrease of the food-fishes, the methods to be adopted for their restoration, the economical and natural

history of the more important species, and the general results of the work of the past two years.

B—GENERAL CONSIDERATIONS ON THE LAKE-FISHERIES.

3.—INVESTMENT IN THE FISHERIES.

The fisheries of the lakes are an industrial interest of large extent and considerable commercial value, of which little is known except among those directly interested.

Back from the lakes the very prevalent idea is that fishing is an unprofitable employment for an irregular class of men who eke out a meager subsistence from year to year by this pursuit. Though the risks and uncertainties of this vocation make the yearly income very variable, the investments of fishermen in their stocks are quite respectable sums, and compare favorably with the farming-communities, being all the way from three hundred to twenty thousand dollars, their sales reaching in some instances as high as $7,000 from their own nets. This refers to those men only who actually superintend their own fisheries. A few dealers who furnish the nets on shares sell five or six times as much in a year. Nor is there any truth in the aspersion on the class of men, who are industrious, hard-working citizens, and, considering the hardships and exposures incident to their calling, singularly free from the habit of hard drinking.

The fishing-stocks are necessarily a less stable investment than farming-lands, liable to frequent loss and injury, and as the success of a fishing-season depends much on the character of the weather, there is of course uncertainty in the yearly income.

The same as in other vocations, the alternation of abundance and scarcity does not develop the provident faculty that accumulates property, for though as a class not given to dissipation, they spend their money freely for comfort and good living when the fishing is prosperous. In spite of all these unfavorable conditions many attain comfortable circumstances.

The investment of fishermen and net-owners by itself is not inconsiderable. Under your instructions last year I visited nearly all the fishing-ports on Lake Michigan, and made an accurate count of the fishing-stocks owned and used on the lake.

In the following pages are given the statistics of permanent investment, of the number of men employed, and their wages, for the year 1871.

Investment in fishing-stocks on Lake Michigan in 1871.

281 pound-nets, average value $500	$140,500
102 gill-nets, "heavy-rigs," average value $725	73,950
348 gill-nets, "light-rigs," average value $225	78,300
98 boats, average value $500	49,000
348 Mackinaw boats, average value $100	34,800

143 pound-net boats, average value $50	$7,150
100 anchor-boats, average value $25	2,500
4 steam fishing-boats, average value $1,800	7,200
1 schooner	3,000
500 shanties, average value $50	25,000
100 ice-houses, average value $100	10,000
Total of fishing investment	431,400

The current working capital employed in the fisheries, omitting wages, and including packages, inspection, salt, ice, freightage, and repairs, is a large sum of money, probably as much as $150,000.

The number of men employed by the nets of each kind is very uniform.

For three pound-nets, a crew of five men is necessary, while where but one or two are employed, at least four men are required.

The "heavy-rig" gill-net stocks, working a large boat, and four and five gangs of nets, with from twenty-five to thirty-six nets to the gang, have five, or six men to the crew.

The "light-rigs," with a 22-foot "Mackinaw boat," and three or four gangs of from eight to twenty nets, have a crew of two or three men.

It will be observed that the boat is the unit of a fishing-stock. It is so considered among gill-netters, as they speak of so many boats "light-rig," or "heavy-rig," in a locality. It has not been adopted among the pound-net men, though it would apply nearly as well.

Though the number of boats represents the number of separate establishments, they do not, however, correctly number the proprietors. There are net-owners on the lakes who have from twenty to thirty thousand dollars invested in nets, and who furnish nets and full outfit to as many as forty establishments, in the "light-rig" gill-net fisheries; the fishermen, in the parlance of the lakes, "filling" the furnished half-barrels on shares.

On Lake Erie there are net-owners who employ a sufficient number of men to run forty pound-nets, paying wages and receiving all the fish. On the other hand, the majority of establishments, managed by the owners, are partnership concerns.

Out of about two thousand men engaged in the fisheries of Lake Michigan, but a few more than half are men receiving wages, and some of these are the minor sons of the proprietors.

The time for which the men are hired varies in different localities. In a large region of the lake-fishing, the season lasts from seven to eight months.

As early as the month of April, before navigation has opened, the fishing-boats are plying daily from their harbors to the fishing-grounds, often finding the run of fish plentiful at this season. In 1871, many of the fishermen began the season before the middle of March. In the fall they prolong the work late into November and even December, and in very open winters, from a few ports, nets have been set, within

three or four miles of the shore, every month in the winter, continuing the fishing throughout the year.

Where fishing through the ice is carried on, men are employed for winter work.

On Lake Michigan, in 1871, the summer fishing in the vicinity of Waukegan, Ill., afforded employment to about forty-four men during three months of the year; the spring and fall fisheries of the lake employed about eleven hundred and eighty men during five months; the year fishing employed about seven hundred and sixty-five during about seven months; in all, about one thousand nine hundred and eighty-nine men, of whom only about nine hundred men received wages. The total outlay was about $180,000 in the season.

4.—THE EXTENT OF THE LAKE-FISHERIES.

No attempt at obtaining any very complete statistics of the product of the lake-fisheries has hitherto been made, and in the census reports of the United States few and fragmentary figures of this large interest have been given. A complete exhibit, or one as complete as may be made of most of the market commodities, would be difficult to obtain, as a large amount of fish is used in the local demand in the vicinity of the fisheries, which is sold directly by the fishermen to residents, peddlers, and traders on steamers, and no account of it is kept. The tables of steamers and vessels are also supplied in this way. There are also a large number of small dealers, who keep no books, receiving and selling fresh fish in lake cities. So that of a large amount of the fish caught no record is made; and of the quantities taken reliable statistics of not more than about seventy per cent. can be obtained.

The handling of the lake-fish on the market employs quite an amount of capital. Large warehouses are necessary for storage and the assorting and inspection of the fish, and are to be found in all of the larger cities. In the salt-fish trade, great quantities of salt come a second time into demand, for use in repacking.

Of late years a process of freezing has been resorted to for the shipment of fresh fish. This process has been patented, and the right sold in all the important cities on the lakes. Large freezing and preserving houses have been erected, and hundreds of tons of fish are frozen while fresh, and shipped in this condition to New York, Washington, Cincinnati, Saint Louis, Omaha, and intervening cities.

Many of the dealers employ small steamers in visiting the fisheries, and gathering in the fish that are salted on the shore.

For the purpose of showing the extent of the fisheries, and their value as a commercial and food resource, we have attempted, since the close of the fishing-season, to obtain an exhibit of the catch of the year, as complete as possible, for the whole extent of the lakes.

Though most of the dealers responded cheerfully to the application for figures from their books, a few failed to comply, and the tables are

in consequence deficient of some large quantities handled by dealers in such places as Toledo, Ohio, and Detroit, Mich., and in a few points of lesser importance. The sales in Cleveland are large enough to compare with those of Sandusky, Buffalo, and Chicago, but the amounts obtained from that city, though cheerfully afforded by all who had them at command, are those only from original points, directly from the net-owners, and the gross sales were not in our possession. By far the larger proportion of the catch of Lake Huron and Lake Superior finds its way into the markets of which we have afforded statistics, and the deficiency of the sum-total of their catch will be what has been shipped into the interior of the State. From these causes probably fifteen per cent. of the quantities put upon the market are not in the tables, while the local consumption before referred to, would add still more to the totals; in all, perhaps, twenty-five per cent.

5.—STATISTICS FOR THE YEAR 1872.

The fishes in the tables are classified according to the system adopted at Sandusky, Toledo, and Cleveland. This system includes under "hard fish" the wall-eyed pike, called pickerel on Lake Erie, *Stizostedion americana* Cuv. and Val.; the black-bass, *Micropterus nigricans* Cuv.; and the *Micropterus salmoides* (Lac.) Gill, mss.; the lake-pike, *Esox lucius* Lin.; the muskellunge, *Esox nobilior* Thomps.; the salmon-trout, *Salmo namaycush* Penn.; and the white-fish, *Coregonus albus* Les. The skinned catfishes, selling for the highest prices in the market, are also included. Under the head of "soft fish" are comprised the sauger, *Stizostedion grisea* DeKay; the white-bass, *Roccus chrysops* (Raf.) Gill; the suckers, *Catostomus communis* Les.; *C. aureolus* Les., *C. melanops* Raf., and the carp, *Carpiodes cyprinus* Les. "Mixed fish" includes both kinds.

**Statistics of the number of pounds of lake-fishes received by first handlers for the year* 1872.

Place.	Hard fish.	Mixed fish.	Soft fish.	Lake herring.	Sturgeon.	Salt fish.
Rochester, N. Y	11, 725	78, 000	....	....	....	....
Buffalo, N. Y	1, 471, 028	....	656, 530	....	....	3, 008, 000
Erie, Pa	193, 446	....	....	....	....	....
Conneaut, Ohio	187, 498	....	....	....	....	....
Ashtabula, Ohio	27, 820	....	....	....	....	....
Cleveland, Ohio	1, 016, 843	....	54, 460	98, 207	....	1, 750, 000
†Sandusky, Ohio	1, 646, 315	394, 405	501, 046	1, 560, 249	720, 500	....
Put-in-Bay, Ohio	85, 000	....	12, 000	146, 600	....	....
Huron, Ohio	197, 891	....	76, 603	913, 252	....	....
Toledo, Ohio	1, 263, 095	....	883, 505	1, 080, 400	....	....
Detroit, Mich	2, 346, 100	....	160, 880	21, 000	....	1, 800, 000
‡Mackinaw, Mich	471, 468	....	25, 000	135, 240	....	....
§Green Bay, Wis	....	662, 000	....	....	....	....
‡Milwaukee, Wis	....	....	....	....	....	852, 300
Chicago, Ill	4, 712, 198	18, 800	17, 784	167, 673	25, 147	2, 619, 500
In the hulls of vessels frozen in on Lake Superior	....	....	....	....	....	270, 000
Total	13, 640, 927	1, 153, 205	2, 387, 808	4, 122, 621	745, 647	10, 199, 800

*All quantities exchanged between the places named, after being recorded for their original market, are deducted from the receipts of the subsequent one.

† The figures opposite Sandusky include both the fresh and salt fish.

‡ Incomplete.

§ Obtained only through newspaper sources.

The sum-total of this incomplete record is 32,250,000 pounds of fish, with a value of $1,600,000.

The two ports handling the largest amount of fish are Chicago, Ill., and Buffalo, N. Y. Their relative figures are shown below:

Place.	Hard fish.	Mixed fish.	Soft fish.	Lake herring.	Sturgeon.	Salt fish.	Total.	Value.
Buffalo, N. Y..	2, 428, 750	....	937, 350	....	....	3, 008, 000	6, 374, 100	$333, 625 08
Chicago, Ill...	4, 712, 198	18, 800	17, 784	167, 673	25, 147	2, 519, 500	7, 461, 104	414, 717 50

Sandusky, Ohio, Detroit, Mich., and Cleveland, Ohio, would also show large figures in their gross sales. The table of statistics, as it shows in most cases only the original quantities received from fishermen and markets not recorded, of course does not exhibit the entire business of the different places.

C—CHARACTER OF THE FISHING IN DIFFERENT LOCALITIES.

The seasons and methods of fishing vary very much in different localities. Slight differences in market demands at various points influence the capture of certain species. Difference in depth of shore-waters controls the range of some kinds of fishes. The season varies somewhat in different parts of the lakes, while the number of nets and men to the boat, as well as the size of the boats, is dependent on numerous conditions.

6.—IN LAKE SUPERIOR.

In Lake Superior, within the bays and among the islands, the pound-nets are used. The bold shores of the greater part of the lake will always prevent the use of these nets to any very injurious extent; though, from the local habit of the white-fish, some of the best localities may become depopulated.

The principal fisheries are in the region of the Apostle Islands and at White-Fish Point. In both places pound-nets are in use, but the gill-nets are, thus far, used in greater number. The other fishing-localities of consequence this season were at Grand Island, Marquette, islands to the east of Keweenaw Point, and Superior City. The Canadian fisheries, except those of Michipicoten Island, are principally under the Hudson Bay Company's control, at Michipicoten River, the Pic, and at St. Ignace Island, and are all gill-net fisheries.

7.—IN LAKE MICHIGAN.

As the fisheries of Lake Michigan were worked up in detail in the year 1871, a description of the character of the fishing in different localities may be valuable for the light it may afford as to the necessity of discrimination in legislating for different regions.

Beginning at South Chicago, near the head of the lake, there were ten pound-nets, distributed along about eleven miles of coast, lying three miles to the north and eight miles to the south of the Calumet River. Unlike pound-net men in other portions of the lake, they here seek to catch every variety of fish, finding sale to the peddlers of everything but the dog-fish, *Amia calva* Lin.

At Chicago there were six boats fishing with trot-lines off the mouth of the river; their catch being almost entirely the perch, *Perca flavescens.* One man is employed during the season at Milwaukee catching bait, shipping tubs full of minnows daily.

There has been no net-fishing here for years, the few experiments made proving failures. It is quite possible, now the filthy current of the river no longer flows into the lake, that there may be some success with nets.

At Evanston, the pound-net fishing was of very much the same character as at Calumet. At both points they have a spring and fall season, taking out the nets in hot weather, when the fish leave the shoal waters.

From Lake Forest and Waukegan to the Wisconsin line were twenty-seven pound-nets, fishing for both the fresh and salt fish markets. In this region comparatively few fishes are taken other than the white-fish. One proprietor has built a smoke-house, preparing and boxing the smaller white-fishes for the Chicago market, where they are sold as smoked herring. If there were no other objection to the capture of the small white-fish, than their useless destruction, this could be easily remedied by disposing of them in this way, as they find a quick and profitable sale, the demand being far in excess of the supply.

The season here is different from most other parts of the lake. Instead of a spring and fall season, with an interim of two months, in which the nets are taken out, the fishing, beginning late in May, lasts until the first week in September; the fisheries having their greatest run during the months in which the least fishing is done at most points on the lake.

It will be observed that in Illinois's share of the lake-shore no fishing is done, save with pound-nets. It is not likely that gill-net fishing would be undertaken here if pound-nets were prohibited, as it would be too hazardous of life and property. Gill-net fishing is adapted only to a coast with good boat-harbors, or at any rate favorable lees, as in high winds, driving heavy seas on the shore, there is great difficulty in landing, and often when there is not sufficient sea outside to prevent taking up the nets, it is very difficult to launch a boat that would experience no inconvenience when once fairly out from shore; so that nets from a shore like this often remain out for days, while a few miles off from a harbor the boats run out and take up every day. Frequently they are caught in a gale when outside, and are obliged to run for harbors twenty or thirty miles to the north or south because of the danger they would incur in beaching. The large number of deserted fish-

ing-shanties along the beach, on the east shore of the lake, attests the impracticability of gill-net fishing from a lee shore.

In this extent of shore there is no spawning-ground known for either the trout or the white-fish, though the fishing is not carried on sufficiently late in the season to find the species named upon their spawning beds.

From Kenosha to Sheboygan are some thirty boats, working the "large gill-net rigs," having from five to six gangs to the boat, and from twenty to thirty nets to the gang, making the string of nets a mile or more in length, and requiring a crew of five men. They run out from shore from eight to twenty miles, according to the range of the white-fish and trout at different seasons. The boats used in this region are principally what are called the "square stern."

At Kenosha five of the boats are "Norwegians," and one a steamer, remodeled from a large "Huron boat."

At Milwaukee, for a time, the most of the boats were the sloop-rigged "Norwegians," afterwards abandoned, and the square stern adopted; and during the past year small steamers were substituted for some of these.

On this line of coast, and farther north, where steamers land daily, the bulk of the catch is shipped fresh, in ice-boxes, to the Chicago dealers.

In the northern half of this extent of shore there are some twenty-four pound-nets, for the most part packing their fish, as the steamers do not land at the points where they are located.

The catch throughout this region is almost wholly white-fish and trout, the gill-nets in the spring and fall taking a quantity of "lawyers," *Lota maculosa*, that are thrown away as useless, except where a small local demand is supplied in the towns. The spawning-grounds begin to the southward of Racine, Wis., and are found northward along the whole extent of shore.

At Two Rivers, and north to the islands, the boats are "Mackinaws," working the lighter rigs of gill-nets, with from eight to twenty nets to the gang, and three or four gangs to the boat, with a crew of from two to three men, and running out from shore seldom more than seven or eight miles.

This is the character of the fishing with gill-nets—after excepting the Door Islands, where a few steamers and large sail-boats are used—for Green Bay and its islands, the north shore, the Beaver, Fox, and Manitou groups of islands, and the east shore of the lake, as far south as Manistee. The gill-net catch, throughout this line of coast, is little else than white-fish and trout, except in Grand Traverse Bay, where the black-fin, *Coregonus nigripinnis* Gill, (Mss.) is found abundant.

At Point aux Barques and Seul Choix Point, a large type of the *Coregonus albus* is taken, feeding principally on the *Mysidæ*. Fishes of eight, ten, and twelve pounds are common in every lift, while as high

as eighteen pounds are claimed to be occasionally taken. Gill-nets with a mesh of five inches are in common use in this vicinity.

The pound-nets, from the head of Green Bay as far north as Peshtigo, take little else that are made use of but lake-herring. A few pickerel and wall-eyed pike—dories, as they are called here—are packed, while sturgeon are thrown away.

From Peshtigo, north, the catch is principally white-fish, with a few trout, pike, and sturgeon. In this region of shoal waters these nets are frequently set four and five miles from shore, some of them in forty-five feet of water.

The west shore of Green Bay is the great pound-net region of the lake, about ninety pound-nets having been in use the past season.

Green Bay is the home of the wall-eyed pike, or dory, *Stizostedion americana*—as they are here in larger numbers than in any other part of the lake.

The sturgeon are taken in great abundance in this region, and are almost universally destroyed. They come into the nets in great numbers in the early fall, and are pulled into the boats with the gaff-hook, and thrown upon the offal-heap.

A pound-net, one long leader with a pound at each end, was set at about six miles from the land, off Big Bay de Noquet, on a 36-foot shoal. The proprietors owned a small schooner, which they kept anchored alongside. They did remarkably well, catching a large grade of fish.

From Seul Choix Point, eastward to Mackinaw, and southward to Little Traverse, Michigan, the pound-nets are used with success. In Grand Traverse Bay, and at Leland, they succeed during the fall season; but from this point south, along the east shore of the lake, pound-net fishing has proved an entire failure and has been abandoned.

From Manistee, south to Michigan City, the larger gill-net rigs again come into use, with four and five men to the boat. The fishing is done from seven to ten miles from the shore, until, near Saint Joseph, the "run out" reaches from twenty to twenty-five miles. There is no spawning-ground from Saint Joseph southward, and consequently no late fall fishing.

From Manistee, south, the bulk of the fish caught are packed in ice and shipped fresh to Chicago, and a few to the interior of Michigan.

In the winter season, after the surface of the water in Green Bay has frozen to a sufficient thickness, the fishing is again begun to a limited extent. Holes are cut through the ice, with chisels made for the purpose, and baited hooks are lowered, in hopes of finding a school of trout in the locality. If unsuccessful, other holes are cut at a distance apart, until the fish are found, when they are hauled out as fast as they bite, a fisherman taking from twenty-five to seventy-five a day, weighing from one hundred to three hundred and fifty pounds, which are hauled home at night on a hand-sled.

Gill-nets are set beneath the ice, by cutting holes a rod or more apart, and sliding a line along from one hole to another, until the desired distance is attained, when a gang of nets is attached and drawn through. The fisherman has a shanty, placed on runners, with a section of the floor removed, and with a good fire in the stove, within a few feet of him, he lifts his nets and removes the fish, entirely protected from the weather.

During the past winter, a pound-net was allowed to freeze into the ice, and a shanty built over the crib, or pot, so that it could be lifted through the opening, daily, without inconvenience.

8.—IN LAKE HURON.

On the greater part of the American side of the Lake Huron shores the fishing is done with gill-nets. There are a number of pound-nets in use in Saginaw and Thunder Bays, and a few at other localities. Seine-fishing for the wall-eyed pike is done on a large scale near Bay City, Mich., on Saginaw Bay.

Except at the northern end of the lake, the large Huron boat is used in the gill-net fishing, and gangs of from thirty to sixty nets are set at from eight to twenty-five miles from shore. At the northern end of the lake the Mackinaw boat is used, with fewer nets.

The fisheries of Saginaw Bay are somewhat unique in character. Gill-nets are set in the ordinary season from the shores near the entrance of the bay. Pound-nets are numerous on both shores up to the mouth of the river; as many as two hundred have been in use at once.

Close to the mouth of the river are the seining-grounds. Four or five 80-rod seines are in use on each side. On the one side where the current sweeps shoreward they are made of coarse twine and have heavily leaded lines, and are strong enough to carry ashore slabs, logs, and everything found in their way. The seine is laid out up-stream, and the current sweeps it on the shore below, when lines are made fast to the bag and it is drawn out by means of a 2-horse windlass. On the opposite shore, where the current sweeps out, there is the necessity for lighter seines and heavy leads, as there is a tendency to lift the lead-line from the bottom and allow the fish to escape underneath; a difficulty that is said to have never been entirely obviated.

As soon as the ice leaves the river in the spring, the seines are swept over the grounds, and usually immense quantities of wall-eyed pike, *Stizostedion americana*, are taken; several tons are sometimes secured in a single haul, and the result of the seasons' fishing is often two thousand packages. The fishing only lasts about three weeks.

The pound-nets take a variety of species. The wall-eyed pike is the more numerous species, and the white-fish next. The fall fishing is said to be the more important for this class of nets.

The winter fishing is very extensive. Holes are cut through the ice and gill-nets are set, pound-nets are allowed to freeze in, keeping only the

surface of the crib open. Wooden "lure-fish" are used attracting the Mackinaw trout to the holes, where they are taken with the spear. Temporary houses are built upon the ice, until quite a village grows up, and traders take out small stocks of goods and establish stores.

There is the most evident reduction of the quantities of fish taken throughout the shores of this lake within a short term of years.

9.—IN SAINT CLAIR AND DETROIT RIVERS.

At the head of Saint Clair River, large fisheries were in operation several years ago, but the enterprise has gradually diminished, as the fish became fewer in numbers, until now three or four fisheries have the fishing-privileges almost entirely to themselves.

Between the mouth of Detroit River and the city are a number of fisheries, employing a large number of men in the fall of the year, and proving as lucrative to their proprietors as any fisheries on the lakes.

The "Ponds" of Detroit River.

These fisheries, known as ponds, are among the most extensive establishments of the lake. Large numbers of white-fish are kept alive in them, from the fall of the year to late in the winter, when they are taken out, and sold in the market at good prices. The best ponds are situated at islands in the middle of the river, where there is an ample circulation of water, keeping the fish in vigorous, healthy condition for months.

The pond is merely an inclosure in the river, made by driving piles close together, and afterward sheathing the inside with planks, leaving joints of three-quarters of an inch width, to allow the free circulation of water through the pond. At one end of the pond a gate is put in, hinged at the bottom of the river to a mud-sill, and the upper portion, floating at an angle of about 45°, projects a foot or more above the surface, closing the entrance to the pond. By pushing the gate beneath the surface, with a pole, it is opened to the extent of one, two, three, or more feet, according to the depth the top of the gate is pushed down.

The accompanying plate represents one of the best arranged and conducted fisheries on Detroit River. The buildings for the men, the net-house, and the store-house, with the windlass-sheds, are all in view. It will be seen that the fishing is carried on by sweeping a seine in front of the pond, that is drawn in by horse-power. When the brails come on shore the men haul in the seine until the bag is reached, when the leads are thrown over the top of the gate, which is then pushed down, leaving an open space at the surface, of two feet, through which the fish are emptied into the pond without being touched by the hand, or taken above water.

At this fishery the seines in use are about one hundred rods long. A gang of thirty men are employed from September to the middle of November, working in two relays, night and day, and averaging about

one sweep of the seine every hour. In each pond from twenty-five to forty thousand white-fishes, and a number of other species, are penned up every season.

There are nine ponds belonging to American proprietors, and seven belonging to Canadians.

10.—IN LAKE ERIE.

Lake Erie produces large quantities of food-fishes of several varieties. The wall-eyed pike—pickerel, as it is incorrectly named in the region—the blackbass, the white-fish, the lake-herring, the salmon-trout, and the sturgeon, are all staple fishes; while, besides these just named, a number of species of inferior food-fishes are shipped from the western portion of the lake, under the general class of "soft fish."

The large quantities of fish that have been taken from the western part of this lake indicates the fact that shallow waters are more productive of numbers than the deeper regions. And this is not only established by comparison with the other lakes, but is confirmed by the fact that the eastern, deeper, and larger portion of Lake Erie does not produce anyhing near the quantities.

The western end, from near Huron, Ohio, is shoal, full of islands, and a very great number of pound-nets are in use, the fish being carried to the adjacent towns; Sandusky receiving the largest share. In the other part of the lake gill-nets are principally used.

11.—IN LAKE ONTARIO.

From the information received from Lake Ontario, it is evident that the fisheries are more reduced than in either of the other lakes. There are few fishermen engaged on the American side, and but a comparatively small supply of fish afforded.

12.—BOATS USED IN THE FISHERIES.

The boats used in the fisheries are of several kinds and constructed on very different models. The "Mackinaw," the "Huron," or "square stern," the "Norwegian," and the "pound-boat," are the ordinary boats.

The famous "Mackinaw" of the lakes has bow and stern sharp, a great deal of sheer, the greatest beam forward of amidships and tapers with little curve to the stern. She is either schooner-rig, or with a lug-sail forward, is fairly fast, the greatest surf-boat known, and with an experienced boatman will ride out any storm, or, if necessary, beach with greater safety than any other boat. She is comparatively dry, and her sharp stern prevents the shipment of water aft, when running with the sea. They have been longer and more extensively used on the upper lakes than any other boats, and with less loss of life or accident. The objection to the more general use of the Mackinaw is that her narrowness aft affords too little room for stowage. They are employed entirely with the light-rig gill-net stocks, and are usually from twenty-two to twenty-six feet in length. Lake Superior, the northern half of Lake

Michigan, and a large portion of Lake Huron, are the regions where they are in general use.

The "Huron" or "square stern" is the boat in most general favor where the large gill-net rigs are employed. It is the ordinary model of a schooner-rigged sail-boat, with less sheer than the Mackinaw, but with plenty of room for nets, fish, or half-barrels. The better models are faster than the Mackinaws. They are generally from thirty to forty feet in length; in most of the regions where they are employed the fishing is done much farther from shore than in the "light-rig" localities. An inquiry into the history of loss of life and accidents among the fishermen of Lake Michigan indicates that these boats had suffered the most, partly, no doubt, because of their longer runs out from shore.

The "Norwegian" is a huge, unwieldy thing, with flaring bows, great sheer, high sides, and is sloop-rigged. She is absolutely dry in all weathers, and though perfectly safe, and with ample room, she is only used by the Scandinavian fishermen, most other fishermen objecting to her slowness and the great labor of rowing in time of a calm. These boats are in use in but very few localities. They are from thirty-five to forty feet in length.

The pound-boats in use in the western end of Lake Erie are very well adapted to the purposes for which they are employed. They are flat-bottomed, wide-beam, very simply-made boats, with a large center board, and carrying two very tall spars, and a wide spread of canvas. They are quite fast before the wind, and very roomy. They are used in transporting the fish from the nets to the warehouses and freezing houses. They are usually forty feet in length.

The ordinary pound-net boat is flat-bottomed, is made from rough boards, and managed with oars only.

The small steamers now used in a few localities are built much after the model of the small river-tugs, but with no upper works, and with wide hatchways extending along half the length of the deck. They are used only with the heavy gill-net rigs.

D—THE DECREASE OF THE FOOD-FISHES.

The special investigation in reference to the decrease of the food-fishes was prosecuted among the fisheries of Lake Michigan. The impression prevails that there is an alarming diminution of the food-fishes of the lakes. This is the ordinary feeling among dealers, a majority of the fishermen, and the people generally.

The supply of fish for the Chicago dealers has steadily increased with the demand, for a number of years, until this season. This is their testimony, and is evidenced by statistics of inspection, kept on file among the city's papers since 1854. This is to be attributed to the fact that the territory fished over has increased in this lake, and that, wherever the lines of steamers and railroads are extended, fisheries are established at new points. From Lake Superior, too, since regular communication

has been opened, a large amount of fish has been shipped to the Chicago market.

13.—THE EVIDENCES OF THE DECREASE.

Statistics to prove decrease are hard to find, as but few records are kept in the localities where the fish are caught; when they have been preserved they show an evident diminution.

The summing up of shipments from the pier at Two Rivers, Wis., affords the following:

	Pounds.
1867.	
Fresh fish	332,000
Salt fish, 6,351 packages	635,100
1868.	
Fresh fish	153,950
Salt fish, 4,679 packages	467,900
1869.	
Fresh fish	185,350
Salt fish, 3,661 packages	366,100
1870.	
Fresh fish	203,100
Salt fish, 2,811 packages	281,100

At this port the decrease has been fifty per cent. in four years.

A firm in Mackinaw, receiving yearly a large amount of fish, by reference to their books gave the following figures, as totals of shipment: In 1869, 17,000 packages, of one hundred pounds each; in 1870, 13,000 packages; and though they had not carried out their records for 1871, said they would fall very much short of the figures for 1870.

The best evidence of decrease in the numbers of the fish is the testimony as to the few nets used formerly, with the same or greater success than is had now with about three times as many. Formerly, too, many of the nets were made of coarse cotton, not as well adapted for entangling a fish as fine linen twine; the mesh used was one-fourth of an inch larger, and, it is claimed, the fishing was done much nearer shore.

More labor, more expense, and more skill in the construction and use of nets are required now than formerly, and for the capture of a less quantity of fish.

The white-fishes are smaller now than formerly; in early times it is said that on an average fifty gill-net fishes would make a half-barrel; now it requires about eighty or ninety.

Of the staple fishes taken in the lakes—white-fish, *Coregonus albus;* trout, *Salmo namaycush ;* herring, *Coregonus clupeiformis*—there has been an evident decrease of the white-fish and the trout.

Occasionally, after several years of small encouragement to the fisheries, at some point hopes are revived by a heavy run of fish upon the shore. The investigation for decrease cannot be understood from the quantities of fish taken at isolated places; the fishes are not by any means distributed evenly throughout the lake, but range in large colonies

and run near the shore at different points, while the majority of localities may be entirely destitute of fish.

14.—WHEN THE DECREASE BEGAN.

The oldest fishermen I have met claim from twenty-five to twenty-eight years' fishing in the lake. They assert the fish to have been abundant, running in near shore, and that hauls of large quantities were made with the seine.

The custom in many places was to employ the Indians to watch the shore for a near run of fish, and when discovered draw the seine around them. Immense quantities were taken in this way.

There are no recorded statistics that show a reliable calculation of dates, but the testimony of fishermen, dependent on their recollection of their purchases of nets and changes in their modes of fishing, places the beginning of a marked decrease within about ten years.

15.—THE AMOUNT OF DECREASE.

The amount of decrease, in the absence of statistics of capture, cannot be decided very definitely. The records of shipments from Two Rivers, on a previous page, show a decrease of fifty per cent. in four years.

The reduction in the number of boats at different localities, perhaps indicates to some extent the amount of decrease in the fish.

In 1858 there are said to have been thirty-three gill-net boats, fishing from Milwaukee, Wis. In 1871 there were but fourteen.

Between Kenosha, Wis., and Chicago, Ill., the pound-nets have diminished from thirty-six in 1869, to twenty-seven in 1871.

At White-Fish Bay, Door County, Wisconsin, formerly an extensive fishing-ground, there are now but three pound-nets.

A profitable fishery at North Bay is now entirely abandoned. The pound-net fishermen at Two Rivers complained of the scarcity of white-fish, and one asserted that a law prohibiting pound-net fishing would not be a very serious loss, in consideration of the poor success they had had for a few years. Compare this condition of things with the record of 1864, in the report of Hon. Theodore Wendell to the Michigan legislature, in which, from four pounds, 2,800 half-barrels of fish were taken in White-Fish Bay, Wis., and with a few more nets a firm of fishermen, Sage & Douglas, took 4,000 half-barrels in the same region. The pound-net men generally acknowledge the decrease of the fish in their own localities, and attribute it to various causes.

At Ausable, Mich., on Lake Huron, there are said to have been forty-two boats in 1865; while at present there are but six.

The estimate of decrease, within safe calculations, is all of fifty per cent., which, in a period of ten or twelve years, is sufficiently large to be alarming.

16.—THE CAUSE OF THE DECREASE.

If the take of fish, by nets of all kinds, is greater than the natural

annual increase, the numbers must of course diminish, and over-fishing is to be considered in investigating the causes of decrease. Still, it is very evident that much more wholesale causes than merely the number of nets in use exist in the lakes, the principal one being the capture in large numbers of small fishes by the pound-nets.

The taking of full-grown, mature fishes, so long as all are preserved and used for food, cannot be questioned as a legitimate and rightful occupation. The capture of half-grown, immature fishes is less legitimate, not only from the fact that the number is diminished by the amount taken, but that the supply of full-grown fish in the waters throughout a term of years, being no greater than the demand, it is evident that if this demand is filled from half-grown individuals their numbers will diminish from year to year at an accelerating rate. And this accelerating ratio of loss is seen to be multiplied many times, when we take into consideration the fact that the supply is barely kept up if only those fishes are taken which are sufficiently matured to have spawned once or twice, while the destruction of fishes, too young to have spawned, must reduce the natural increase by perhaps hundreds in the death of each one.

If every fish that had passed the precarious embryonic stages and developed into a thrifty swimmer of four or five ounces, had been allowed to mature, and to spawn once or twice before it was taken out of the water, the supply of white-fish would not have diminished to any great extent.

The capture of immature fishes is, without doubt, the principal cause of a decrease.

The taking of fish in too large quantities to allow of handling and preservation, the destruction of fishes too small for use, or of others because they are not in a special line of fishing followed by certain fishermen, or the capture, when used, of those not old enough to spawn, are all entirely wrong and destructive to the fishing-interests.

(16 *a.*) *The pound-nets.*—In observing the lifts of white-fish taken from the pound-nets during the spring and summer seasons of fishing, along the west shore, they were estimated to contain from one-twentieth to one-sixth of small fishes, that, when prepared for salting, entrails and heads removed, would weigh less than eight ounces. These, among fishermen supplying the peddlers, are all made use of. A few fishermen prepare them by a slight salting and smoking, and sell them in boxes, as smoked herring, but the majority are compelled to bury them, as useless, as they are smaller than any grade recognized in the salt-fish market.

The inspection-regulations of the Chicago market, that are accepted throughout Lake Michigan, provide for three grades of white-fish, with reference to size. The inspection is intrusted to the judgment of the inspectors without any very exact stipulations as to dimensions or weight of the different grades.

The standard of inspection, of the best inspectors, which is also approved by most of the dealers, though not establishing the grade by weight, virtually makes the minimum weight of a No. 1 white-fish about one and one-quarter pounds; a No. 2 fish, about three-quarters of a pound; and the weight of a No. 3 fish, from three-quarters of a pound to less; this is after the head and entrails are removed.

On counting pound-net fish, as they were repacked by dealers, fishermen's uninspected packages, one hundred pounds, were found to contain from one hundred to one hundred and eighty fishes; in the latter case the fishes averaging less than nine ounces. Numbers of small fishes, weighing from five to six ounces, are found in the pound-net packages.

Certain localities, as the north shore of the lake, have a large type of fish; but of pound-net white-fish, taken in a season, throughout this lake the average would not be above the No. 2 grade in weight.

An advantage the pound-net has over the gill-net, or seine, in warm weather, is, that in a large catch of fish it is possible to take out just such a quantity at a time as can be handled, leaving the rest alive, and fresh until it is convenient to return for them.

In the gill-nets the lift must all be brought ashore at once, and what can be dressed and packed in a few hours are used, while the remainder spoil and have to be thrown away.

Pound-net fish are generally superior to gill-net fish to ship fresh, because they are always fresh when put in the ice-boxes, while those from the gill-nets may have been dead twenty-four hours or more.

(16 *b.*) *The gill-nets.*—The white-fish taken in the gill-nets, in Lake Michigan, will average much higher than No. 2 fish. From reference to the books of dealers in Chicago, and an extended observation of the gill-net fishing, it is evident that the entire catch of the lake would not give as low an average weight as one and one-quarter pounds. The inspection of fishermen's shipments of gill-net fish seldom affords as low a proportion of No. 1 fish as one-half.

The reasons for the larger size of the gill-net fish are in the facts referred to on another page, in reference to the habit of the immature white-fish to remain near the shore, the least depth employed for the gill-nets, being twelve or fifteen fathoms, entirely outside of the range of the smaller white-fish.

The gill-nets destroy a great many fish in time of storms, when the fishermen are not able to visit the nets for days at a time, two or three days being sufficient during the summer months for the fish to die and become tainted, when they are thrown overboard to rot on the fishing grounds, making it offensive to the white-fish and driving them away.

The gill-nets, when they are lost, destroy fish by entangling them until the floats become water-logged and sink. They have been grappled up, two years afterwards, while searching for nets recently lost, full of decayed fish. This is quite an extensive agency of destruction, as a

great many gangs of nets are lost in the lake every year by heavy storms, and many in the late fall by being left out until storms and ice prevent their recovery.

A species of fish of good size and really fair flavor is destroyed in large quantities in certain localities by the gill-nets, from the fact that there is no demand for it in the general market. This is the so-called "lawyer," the spotted burbot, *Lota maculosa*, one of the family of Gadoids, to which belong the cod, the haddock, and the ling, all well received in the market. The lawyer is rejected because of a prejudice against its appearance. The peddlers in Chicago, and the proprietors of fish-stands in Milwaukee, find no difficulty in selling it. The livers are very large, and are occasionally obtained in quantity, and regarded as a rare dish by experienced persons.

(16 *c.*) *Throwing offal on the fishing-grounds.*—It is the uniform testimony of all fishermen that throwing offal or dead fish in the vicinity of the fishing-grounds is offensive to the white-fish, and drives him away.

The white-fish is peculiarly cleanly in its instincts, and has an aversion for muddy or foul water of any description. Most fishermen regard their own interest sufficiently to be careful in this particular, while many careless and shiftless men injure themselves and others by dumping offal and dead fish anywhere in the lake where they find it convenient, reducing the catch of fish in the vicinity for several months. Unsalable fishes are generally thrown overboard in the vicinity of the nets.

(16 *d.*) *Pollution of lake-water from sawdust.*—The refuse from the saw-mills, slabs, sidings, and sawdust, is thrown into the streams in immense quantities to float out and sink in the lake. It is having a very injurious effect upon the fisheries. The water-logged slabs, tilted on the bottom, and moved by currents, tear and carry away the nets. The sawdust covers the feeding and spawning grounds of the fish, and is so obnoxious to them that in the vicinity of numerous mills, as at Muskegon, Mich., the fisheries become greatly reduced in numbers and success.

The observations of Alfred Blais, a fishery-overseer in the employ of the Canadian marine and fisheries department, discovered the salmon-ova, diseased and decaying, with particles of sawdust adhering. Its contaminating effects extend far and wide from the vicinity of the mills, as the contents of a dredge, from one hundred fathoms depth, in Grand Traverse Bay, contained numerous blackened and decaying particles of sawdust.

The gradual deposit of water-logged sawdust, an inert substance, in the water, with occasional slabs, forms nuclei for sand-bars in the mouths of the rivers, and in some of them will contribute to an injury to navigation, as it has to a considerable extent in the Menominee River of Wisconsin and Michigan.

E—PRACTICABLE METHODS OF INCREASE.

It is a matter of great importance that means should be immediately employed to arrest further decrease in the numbers of the lake-fishes,

and an effort be made to restore them to their former numerous condition.

There are two methods that present themselves to accomplish this purpose. The more efficient one is artificial propagation; the other, necessary as an auxiliary to the first, is legislation.

17.—PROTECTIVE LEGISLATION.

The experience of the past, both in Europe and the older portions of our country, indicates the inadequacy of protective legislation in preventing the decrease and extermination of the food-fishes.

In the compilation of the laws relating to the protection of fisheries in Massachusetts, published in the sixth annual report of the commissioners of inland fisheries of that State, there were three hundred and fifty-nine acts, passed by the legislature of the State between the years 1623 and 1857, involving directly the protection of the food-fishes. In 1857 the first provision for propagation was made. Until this time, though the law had the influence to retard the decrease, it had not prevented it, and the salmon were exterminated, while the shad were reduced in numbers, until the fishing was unprofitable, and their price in the market very high.

The propagation of the shad restored their numbers in a few years until they were more abundant than for fifty years previously in the Connecticut River, where the experiment was made.

The alewives were rapidly renewed in numbers, and the effort is now being made to restore the salmon.

The fish-protection laws of Great Britain date back before the Middle Ages, while the restoration of numbers in the salmon is owing to fish-propagation by the artificial methods within the period of a few years.

This has been the general experience. The effect of the law, when most efficient, has been merely preservative, while that of propagation is restorative.

The greatest necessity in the way of legislation in the lake-region is the protection of the immature fishes from capture and destruction, and this should be the principal aim of laws regulating the fisheries.

To accomplish this, a great many have advocated the entire prohibition of the use of pound-nets, believing it to be the simplest effective way of disposing of the matter. It must be understood, however, that it would work ruin to every pound-net fisherman. The nets and boats are entirely useless for any other purpose than pound-net fishing, and the fisherman's entire property, with comparatively few exceptions, is invested in his fishing-stock, occasionally reaching a figure as high as four or five thousand dollars, and rarely as low an amount as four hundred dollars. Besides, though it would arrest the decrease, it would reduce the product of the fisheries for several years, because of the great decrease in the number of nets, and the whole fishing-interests of the lakes in the market would be embarrassed in consequence.

The possibility of handling the fishes over as they are dipped out of the "pot" or "crib," and sorting small fishes out, to escape, while the larger ones are reserved, has been frequently suggested. The objection to this would be chiefly the fact that, owing to the delicate nature of the white-fish, it would not endure rough handling; and, if the regulation was established, there would be no probability of its enforcement. That it is in some measure practicable, if carried out, may be known from the fact that a fisherman, formerly in North Bay, Wisconsin, took his fish from the pound-net, one by one, and bled them before he threw them into the boat, the smallest were thrown overboard unharmed, and most of them swam off vigorously, though many died from handling. His purpose in bleeding was to pack a firm-fleshed, white-meated fish, for which he received a fancy price from some one in Ohio.

The enlargement of the mesh in the pot or crib is perhaps the most practical regulation that is likely to accomplish the purpose intended without inflicting injustice upon the fishermen. The mesh in present use is from one and one-half to three and one-fourth inches in length, extension-measurement—that is, measured through the length of the mesh-opening when drawn taut. This makes it from three-fourths to one and five-eighths inches from knot to knot. For the capture of herring, the smaller mesh is considered necessary, while, where the object is to capture only white-fish, the larger mesh of three and one-fourth inches is sometimes used.

Comparing the gill-net mesh, usually four and one-fourth or four and one-half inches, with the pound-net mesh, it will be observed that the difference in size is not the only variation in condition to be considered. The fine twine of the gill-net is more unfavorable for the escape of a fish than the coarse twine or cord of the pound-net. Besides, while the gill-net, by means of nicely-balanced floats and weights, stands in the water comparatively slack, the sides of the pound-net are drawn up with the meshes open, and standing taut and firm, are much less apt to entangle a fish while attempting to pass through. It is seen from this that although four and one-fourth inches are small enough, perhaps too small, for the gill-net mesh, the same dimension is not required for the pound-net.

Still, with all the advantage that a taut, open mesh affords them, the habit of the fish to remain quietly in the "pot" until it is lifted to the surface has to be taken into consideration. Of course the greater facility of escape, the greater number of fishes that will avail themselves of it.

It should not be considered an unfair demand that all white-fishes of less size than the minimum of the inspection-grade No. 2 should be allowed the means of escape. By a series of measurements it has been determined that a No. 3 white-fish will measure about seven and three-fourths inches in the girth. This would require for its escape about three and three-fourths inches, extension-measurement, or one and seven-

eighths inches from knot to knot. To allow for shrinkage, after saturation with tar, the mesh when netted should be at least three and seven-eighths inches, extension-measurement.

There are a few localities in the lakes where herring are utilized to a large extent. In the shoal regions of the lakes, and especially in the shallow bays, the lake-herring are abundant. In Green Bay, an arm of Lake Michigan, to the south of the Menominee River, at Mackinaw, Mich., and vicinity, a good many lake-herring are handled, though they are by no means as valuable to the fishermen as either white-fish or trout. In the western end of Lake Erie, especially in the vicinity of Sandusky, Ohio, they are taken in large numbers. In all localities where fishing is carried on with the pound-nets, or near the shore with any nets, herring are taken to a limited extent, and are generally not made use of.

Of course when the fisheries depend on the catch of herring for their support, a large mesh would be fatal to them, and it is doubtful whether a mesh larger than one and one-half inches could be used with advantage.

The statistics of nine principal fish-markets on the lakes show the proportion of lake-herring handled to be one-sixth, while the low rates herring command in the market would produce only about one-thirtieth of the amount realized from the whole quantity of fish handled. This shows the small value of the herring, to the fishermen, in the herring-localities. In the whole product of the lakes it would be of much less consequence.

It will be seen, from the foregoing statements, that a law regulating the size of mesh, to the great advantage of the better species of fishes, would not be very injurious to the fishing-interests as a whole if it allowed the escape of the herring. Still, as the discovery has been made, this fall, that the herring feed very extensively on the spawn of white-fish, there is an advantage in taking them from the lake.

Prohibiting fishing at certain seasons of the year has been an ordinary method of legislation in protecting the fish, and has proved to be of great advantage in streams and inland waters. The great lakes, in the particular of fishing, assume very much the character of the sea, and the same class of legislation, benefiting streams and inland waters, is not required for them.

A close season, from Saturday night to Monday morning, has been recommended by State commissioners of some of the sea-board States. This could be adopted in the case of the pound-nets, but it would not be practicable with the gill-nets, as it would be nearly impossible for the fishermen to take up several gangs of nets on Saturday night, and reset them on Monday.

In the case of the pound-nets, the extension of leaders to great distances from the shore is an abuse of the fishing-privileges, as it obstructs, to too great an extent, the natural runways of the fishes, and

infringes on the rights of other fishermen, on each side, by preventing the access of fishes to their nets.

A law restricting the number of pound-nets to the mile, along the shores of the lakes, would be a favorable regulation.

The gill-netters, though having had much less influence in diminishing the numbers, would assist the increase, to a large extent, if they restored the mesh of the gill-net, now generally four and one-quarter inches, to the original four and one-half inch mesh. A discrimination should, however, be made in favor of Grand Traverse Bay, where the larger portion of the catch is the black-fin, *Argyrosomus nigripinnis* Gill, which does not attain an average weight of more than one pound.

A regulation prescribing the size of meter and seaming, and enforcing the renewing of the same, and also the stretcher-lines of gill-nets, would be valuable, as great numbers of fish are destroyed uselessly by the breaking away, in storms and currents, and loss of the nets in the lakes, which continue to capture fish until the floats become water-logged and sink to the bottom.

The catching of white-fish during the spawning-season, from November 10th or 12th to the middle of December, is often censured. It will be observed that though the ova at this season of the year are ready to be deposited, and produce, in the course of a few months, young fish, there are no more eggs destroyed at this season, in killing such fish, than at an earlier period. Nor is the production of the next season's stock of young fishes any more diminished by taking the same number of fishes from the water in November than in August. The objection to taking fish at this season is, that they run into shoal water, in large schools, and are taken in greater numbers than at any other season of the year.

There is no fault found with the quality of the fish taken in the cold waters of early winter, and the largest quantities can be handled with safety, because of the favorable weather.

The only run of fish the fishermen can look forward to, with certainty, is the run of trout upon the reefs in October, and of white-fish in the shallow waters in November. Though the previous months have been unprofitable, they look forward to this season with certainty of some success if it does not prove too stormy.

There is a wasteful destruction of fish in the killing of sturgeon in certain localities. In the waters of Green Bay they are taken by thousands in the early fall in the pound-nets. The fishermen make no use of them, and considering them an annoyance, draw them into the boat with a gaff-hook, and throw the carcasses on the offal-heap. Thousands of pounds of food are destroyed in this way every year.

The firm of Schacht Brothers have attained quite a degree of wealth during the past six years, in the city of Sandusky, Ohio, by utilizing the sturgeon. They smoke the thicker parts of the fish, making a superior substitute for halibut, manufacture caviare from the ova, isinglass from the bladders, and oil from the thin parts and offal.

Green Bay is, perhaps, the only locality on the lakes where this can be repeated with success, and it is well worth the attention of some one with a small amount of money to invest.*

It is the universal experience of fishermen that throwing offal on the fishing-grounds is offensive to the white-fish and destructive to the fishing-interests in the locality. A stringent law should be enforced in this particular, as it is generally a shiftless, lazy man who is guilty of this injury to his more worthy neighbors, as well as to himself.

In this connection it is well to refer to the fact that sawdust in many lumber-mill localities is thrown into the streams, or is used to bank out in the shoal waters at the edge of a river; great quantities of it floating out and water-logging, settle on the spawning-beds and feeding-grounds of the white-fish, to decay, and drive them from the locality.

With this discussion of the effects of different laws upon the fishing-interests we would refer to the enlargement of the mesh in both pound-nets and gill-nets, prohibiting the throwing of offal upon the fishing-grounds, and the useless destruction of sturgeon, as the most necessary and desirable regulations to be established by legislation.

It will be observed that the varying character of the fishing in different regions requires discriminative legislation in favor of certain localities. Where the lake-herring is the principal fish taken, a mesh larger than two inches would allow their escape. The provision of a close season, during the hot months of the summer, though, it will be seen, it would afford an ample season in the spring and fall for the fisheries in most localities, would debar all successful fishing to the larger extent of the Illinois shore, where this season of the year is the only time when fishing is attempted. The enlargement of the gill-net mesh to four and a half inches, though a favorable regulation for all other portions of the lake, should include an exception in favor of the region of Grand Traverse Bay, Michigan, where the black-fin, a fish averaging much smaller in size than the white-fish, is taken in large numbers.

The Canadian laws are sweeping and stringent in character. By exacting license-fees from the fishermen they control the extent of fishing in all localities, and limit the number ot nets to each mile of the shore in accordance with the judgment of the fishery-officers. Their system of laws and policing the whole extent of shores is an expensive and cumbersome method of protecting the fishes, and it is altogether probable that the large amount of money, $20,195 in the year 1871, used for this purpose, would increase the products of their fisheries to a much greater extent, if expended in the propagation of those fishes adapted to artificial culture.

18.—ARTIFICIAL PROPAGATION.

By far the more successful method, in restoring the numbers of food-fishes, is that of artificial propagation. During the past several years, the salmon in Norway, Sweden, Germany, France and the British isles,

* Since undertaken.

have been increased to a very large extent from the breeding-houses at Huningen, Stormontfield, and elsewhere. A yearly increasing supply of salmon has by this means stocked the exhausted rivers of Canada. The shad and alewives have been restored to many of the eastern rivers, and the brook-trout has been reared in great numbers, and many streams and localities where they had always been unknown have been stocked with this favorite fish.

Of all species except the shad, those of the salmon-family prove to be the best adapted for artificial culture. The eggs are readily impregnated, are specially adapted to being handled, to endure transportation, and lie free and separate at the bottom of the water, incased in an investing membrane thick enough to protect the delicate embryo from the hard contact of the gravel, or glass, or wire screens upon which it is necessary to place them.

(13*a*.) *History of the white-fish culture on the lakes.*—It has already been shown that by far the most important fish of the lakes is the white-fish. The fish culturists in the vicinity of the lakes, having the knowledge of the rapid decrease that had been going on in the numbers of this species for the past few years, appreciated the advantage that their art might afford should the white-fish prove to be adapted to their methods of culture.

Three prominent fish-culturists in the vicinity of the lakes began their experiment about the same time: Mr. Seth Green of Rochester, N. Y.; Mr. Nelson W. Clark, of Clarkston, Mich.; and Mr. Samuel Wilmot, of Newcastle, Ontario, Canada. Mr. Green and Mr. Wilmot obtained spawn in the fall of 1868, and Mr. Clark in the fall of 1869, and treated them in the same manner as the brook-trout. These experiments were all attended with considerable success, though the large percentage of loss, compared with that in trout and salmon hatching, was anything but encouraging. The screens in the troughs, in most instances, were the same as those used for the trout, and the embryo white-fishes, being smaller, escaped and ran over into the waste-troughs, and down into the ponds below. This was in some measure a fortunate circumstance, at Mr. Wilmot's establishment, for the young fish, finding their natural food in the ponds, grew and thrived, and afforded the only positive data there are of their rate of growth.

In the succeeding year Mr. Green and Mr. Clark made additional experiments, and from the experience of the preceding year, having learned the necessity of immediate attention to the white-fish eggs after they were placed in the troughs, began the work of removing the unimpregnated eggs within two or three days' time, and, giving them close attention, during the season hatched out a much larger percentage of eggs. Mr. Green, in 1869, distributed a quantity of the white-fish spawn to numerous applicants who responded to an advertisement offering it for distribution. Some packages of spawn, from this supply, were sent by steamer to Mr. Frank Buckland, inspector of salmon-

fisheries for Great Britain. In referring to the condition of the eggs, on their arrival in London, he says, "A good proportion of the white-fish eggs were alive and well."

Some temporary troughs were put up, in Detroit, Mich., and supplied with the ova, under the direction of Mr. A. M. Compeau, Mr. J. P. Clark, Mr. George Clark, and Mr. James Craig.

Experiments were again made by Mr. Green, Mr. Clark, and Mr. Wilmot, in 1870. More than a million of ova were supplied by the liberality of Mr. J. P. Clark and George Clark, without expense, from their ponds in Detroit River. Mr. Green also made experiments in the breeding of salmon-trout and lake-herring, with some success.

In 1871 these gentlemen just referred to, from Detroit and vicinity, failing to arouse the interest of the State authorities in the matter of fish-propagation, to the extent they desired, furnished Mr. N. W. Clark, of Clarkston, with the necessary funds for the erection of a building, sixty-four feet in length by twenty in width, in which were put up twenty-six troughs, sixteen feet long and one foot wide. The entire building was devoted to the hatching of white-fish, and the number of eggs laid down estimated at about one million. The experience of the previous years aided Mr. N. W. Clark to a most complete success, and by the 1st of April the fish began hatching, and before the 13th of the month the troughs were swarming with young white-fishes. Between the 20th and the 30th of April these were all distributed by Mr. Clark in a number of inland lakes in Oakland County, Michigan, and into the Detroit River.

Mr. Wilmot again procured about one-half million of white-fish eggs, which were handled with improved success.

Mr. Green gave less space to white-fish eggs this season, and laid down large quantities of salmon-trout ova, with the purpose of distributing the trout in the inland waters of the State.

In 1872 an employé of Mr. Green devised a new apparatus for hatching fish, that economized space to a great extent, and afforded him room for a large supply of both salmon-trout and white-fish ova. Visiting his establishment in January last, we found them hatched out in large quantities, and orders arriving daily for the fry, to stock the waters of inland lakes in all parts of the State.

Mr. Wilmot obtained a supply of white-fish spawn at Sandwich, on the Canadian side of the Detroit River.

November 11th I met Mr. N. W. Clark at Ecorse, and in company with Mr. George Clark we visited Grassy Island for the purpose of obtaining white-fish spawn. The box which Mr. N. W. Clark has devised for carrying ova is constructed so as to carry a greater quantity of eggs, with easier carriage, than any in present use. It is a large square can, of zinc, about thirteen inches square and twenty-two inches deep. This, for protection, is set inside of a strong wooden box, with a light frame in the bottom, supported on stiff springs. Strong handles are

fastened to the box, for convenience in handling, and to prevent any necessity for throwing it out of level while carrying it. The zinc can contains ten trays, each of which carries fifty-four small boxes, two inches square and two inches deep, set in compartments, each compartment having an inch hole cut in the center. The partitions between the compartments are just high enough (about five-eighths of an inch) to inclose the bottom of a box, and hold it firmly in its place. No covers are provided for the boxes, but a large cover can be fitted to the zinc can, and a lid, with a good lock, is fitted to the outside box. The bottoms of all the little boxes are perforated, the position of the holes being directly over the circular hole in the compartment of the tray. The zinc can has also holes in the bottom, and the wooden box has three-quarter inch holes bored on each side, near the bottom, so that there is drainage for the surplus water of all the boxes, and a free circulation of air throughout, which is deemed important by some of the fish-culturists.

At the island the most perfect arrangements were provided by Mr. George Clark for obtaining the spawn. Two tanks of about five feet diameter were placed at the edge of the shore and partly filled with water. As soon as the bag of the seine was on the beach the men picked up the white-fish and put them immediately into the tanks. The pans for impregnation were close at hand, and as one man lifted the fish above the water in a dip-net, another took it from the net, and with his right hand over the head of the fish and his left around the tail he held it over the pan, standing at the left of the operator. The left hand of the operator was put against the back of the fish and the right hand used in manipulating the abdomen. It was found that to induce the eggs to flow freely from a fully ripe female, all that was necessary was to apply a gentle pressure just behind the pectoral fins, just where the nudging and bunting of the head of the male fish is applied while racing her through the water. Not until the greater part of the free eggs had fallen into the pan was it necessary to slide the hand along the abdomen. The free eggs came away in a steady, liquid stream, but from a fish partially ripe their extrusion was slow, and in masses comparatively dry, that did not freely disengage themselves from the fish and fall into the pan.

The female exhibited the most indications of pain when the pressure was applied in the vicinity of the ovipore. The milt from the male will flow in from one to three jets by pressure in the vicinity of the anus.

The method employed by Mr. N. W. Clark was that which was original with Mr. Seth Green, using the smallest quantity of water possible. The eggs, after falling into the pan, and the milt having been stirred up with the water, were allowed to stand about half an hour, when the milt and water were poured off and the eggs carefully rinsed through several changes of water. A small quantity of water was left with the eggs when they were perfectly clean.

By repeated actual counts, and by arranging on a plate in a true square, it was found that a large table-spoon, moderately heaped up, contained about a thousand eggs.

Eight ripe white-fish eggs will lie entirely within the space of an inch, and the ninth will lie partially across the line.

A pat of moss was then put into the cups and a piece of canton flannel, cut into the form of the Swiss cross, after thorough saturation with water, was pressed lightly down into the cup, and a table-spoonful of eggs poured upon it. The canton flannel was used to line the sides of the boxes, because it was found that the contact of the zinc was fatal to the eggs, probably from the poisonous elements of the oxide. The patch of canton flannel proved to be a great convenience in taking out the eggs, as all that was necessary was to take the edges lightly in the fingers and remove it from the box, and dipping the cloth with the eggs into a pan of water, they were rinsed off with a few quick motions, without any tedious picking and rinsing the eggs free from particles of moss. In arranging the eggs for transportation for a short distance, the use of the cloth patches is undoubtedly a good method.

After filling the boxes they were placed in the trays, and the trays adjusted within the zinc can, when water was poured on until the whole contents were thoroughly saturated, when the lid was closed and locked and the case was ready for transportation to the hatching-house. A small fee to the baggage-master excites considerable interest in the safe handling of the box.

Two trips were made from Ecorse to the hatching-house at Clarkston, and about one million three hundred and thirty thousand eggs were put into the troughs, Mr. Clark having increased the number of troughs to fifty for the purpose of receiving the extra supply of eggs. One-half of the eggs were the property of the commission, the other half to be controlled by Mr. J. P. Clark, of Detroit, Mr. George Clark, of Ecorse, and Mr. N. W. Clark, of Clarkston. The eggs received attention from the second day after they were placed in the troughs until about the middle of January, the eyes of the embryo then showing distinctly, and the subsequent loss being very small.

Upon receipt of the instructions to ship a quantity of eggs to the State commissioners of California, a case similar to Mr. Clark's was made, substituting a good quality of tin for the zinc, and adding a second square can, large enough to contain the can with the trays and cups, and leave the space of an inch on all sides.

Arriving at Clarkston on the 18th of January, the weather was considered too severe to hazard the shipment of the eggs at the time, and it was delayed until the 20th.

The thick covering of frozen snow and ice prevented the possibility of obtaining moss, and a good quality of sponge was substituted. This was prepared, first, by whipping out the calcareous dust that it contained, and, after being cut in thin slices, was thoroughly washed

through several changes of warm water. Pieces were then fitted to the bottom of the cups, and while standing in a pan of water, a half table-spoonful of eggs was poured in, a thin slice of sponge, fitting the inside of the cup, laid lightly over the eggs, and the remainder of the spoonful poured in, when a third piece of sponge was put over them to cover them. The tray, with the cups, was then put into the inner can, which was placed within the second can, with one inch of sawdust filling the vacant space on the sides, bottom, and top. A piece of burlaps was tied over the top, and the whole placed upon the springs, within the packing-box, and the lid fastened down. The packing-box had two half-inch holes bored near the bottom to admit the air. The filling of sawdust was considered as a necessary safeguard against the cold weather of the time.

The case was put in charge of the baggage-master, and I accompanied it as far as Omaha, Neb., attending to its transfer from one train to another, and regulating its position in the car. At Omaha it was given in charge of the express company, and the messenger instructed as to the effect of heat and cold upon the eggs, and a letter containing full instructions sent with the box to be delivered to the messenger at Ogden, where the box was transferred to his care, there being no further change of messenger between that and San Francisco, Cal. On two sides of the box, in distinct letters, was printed the caution, "Fish-eggs; must not be jolted or allowed to freeze."

The weather continued cold throughout the time the eggs were on the way, and they arrived at their destination in very bad condition. Mr. Stone attributed the damage to the use of sponge, and the sawdust-packing preventing ventilation. Mr. Rudolph Hessel, an experienced fish-culturist of Offenburg, Germany, while visiting Washington, informed me that he had used sponge for packing eggs for long distances with entire success. The lack of ventilation is a more probable cause, though the description given by Mr. Buckland of the method of packing the eggs received from Seth Green's establishment in January, 1870, was similar in the fact that the cups containing the moss and eggs were buried in the sawdust. A small quantity, received from Mr. N. W. Clark, at the Smithsonian Institute this winter, was packed in the same manner, using sponge and burying the cups in a pail of sawdust, and they were found to be all alive after a fifty hours' journey.

The necessity of a certain supply of oxygen to the eggs has been very thoroughly proven by the researches of W. H. Ransom, M. D., of Nottingham, England, published in the first volume of the Journal of Anatomy and Physiology. The experiments were made while investigating the nature of the rhythmic contractions of the yelk, known to occur in the living eggs of fishes. Among several experiments, in which, by ingenious methods, the oxygen of the atmosphere was kept from contact with the eggs, those of the stickleback being employed, he relates as follows:

"I therefore made a series of suffocative experiments on impregnated and unimpregnated eggs, using aerated distilled water in cells, all of the capacity of .05 cubic inch, sealing the covers with hot wax, and varying the number of eggs in each cell.

"Five observations were made with unimpregnated eggs, having, respectively, 35, 30, 18, 9, and 7 eggs in a cell; and although, in consequence of the accidental loosening of the wax, and the entrance of a little bubble of air, the duration of the contractions was not in all cases inversely as the number of ova in the cells, yet the general result was that both the rhythmic contraction and the pseudo cleavage continued longer in the cells containing the smaller number of ova, the eggs which lay nearest to the air-bubble always being the last to cease to move; the accidental failure of the luting affording thus additional evidence of the importance of oxygen. In all the cells the contraction ceased in from 23 to 30 hours, or one-fourth of the time they continued in aerated water and unlimited space. Five similar observations were made on impregnated eggs, with 48, 38, 17, 10, and 7 eggs in each cell, with similar but more marked results; the yelk-contractions ceasing earlier than in the unimpregnated ova. The cleavage was more rapidly checked than the pseudo cleavage, and still more so than the yelk-contractions.

"Seven experiments were then made to ascertain the relative dependence upon the presence of oxygen of the movements which result in cell multiplication and differentiation, and of the muscular contractions of the embryo compared with the yelk-contractions.

"Two healthy developing ova were sealed in similar cells at 76, 101, 127, 150, and 174 hours each, after impregnation, and two free embryos at 24 and 48 hours after hatching. Although the proportion of active organic matter to the medium was so very much less than in the previous experiments with recently-impregnated eggs, yet the process of development ceased in all in about 7 hours, and the yelk-contractions did not continue more than 18 hours. The movements of the heart continued about the same time, those of the trunk ceasing before the heart. The embryos in the later stages of development more quickly ceased to move than those in the earlier.

"The inference is, I think, not to be resisted, that oxygen in the surrounding medium is an essential condition of the exercise of the property of rhythmic contractility possessed by the food-yelk, as well as of the fissile contractility of the formative yelk."

Though Dr. Ransom admits that the quantity of oxygen consumed in these movements appears to be very minute, yet it indicates that a large quantity of eggs confined in a small, air-tight space, would consume the oxygen to an injurious extent, during a long journey, and sufficient ventilation is to be considered as one of the necessities in packing eggs for transportation.

The sawdust that filled the space around the inner can, in the Cali-

fornia shipment, was crowded down with a piece of board, and may have, in consequence, rendered the package more completely air-tight than in the shipments referred to similarly packed.

A later shipment arrived in most excellent condition. The cups in the cases were made four by four inches square, by two deep, with no packing between the cans, and the eggs packed in moss. The most ample ventilation was provided for in the egg-cases.

The oxygen given off by live moss is probably the principal reason for its special adaptation in packing eggs for shipment.

Dr. Ransom's experiments on the effect of heat have also a practical value in the treatment of fish-ova, both in transportation and in the troughs. He says: "Some eggs in the stage of active contraction were cooled until the thermometer placed on the cell stood at 32° F. They all became still, and their yelks globular. They were not frozen; and I do not doubt that their temperature was higher than that indicated by the thermometer." The contractions were afterwards restored by a weak galvanic current. In another observation "I froze the water in which the eggs were placed, so that some of them were completely, and others incompletely, frozen. The frozen eggs were all more or less opaque, and had their inner sacs ruptured, and emptied of yelk in various degrees, and their formative yelks lobulated, and darkly granular. Those which were least frozen were slightly opalescent only, and when allowed to thaw they contracted as before, ultimately going on to cleave in an irregular manner, the ruptures in their sacs having healed. Slighter reductions of temperatures to 40° and 48° F., retarded without destroying the contractions. In such cases the commencement of cleavage was delayed. By raising the temperature moderately the movements were accelerated; but at about 80° F. (it is difficult to speak with certainty of the temperature actually obtained by the object) the contractions were arrested; the yelk-ball becoming globular, and the oil-globules being scattered. Such eggs, however, soon recovered themselves when left at 58° F., and cleft in even less time than eggs did which had not been warmed. In other eggs, heated in a chamber at 102° F., the cleavage was retarded to three times the usual period, and when it took place was wanting in symmetry. The yelk began to become opalescent at about 103° F.; but a true coagulation of the albumen did not take place, the yelk being fluid, and opaque. Thus a temperature too low or too much elevated retards or arrests the contractions, but they are not destroyed before commencing physical and chemical changes set in."

Whether the point at which the contractions of the yelk ceased was the point at which vitality left the egg, might or might not have been the fact, but it is quite evident that the egg was, at the temperatures stated, in an abnormal state, and the necessity of sustaining a temperature around the eggs of fishes between these extremes is apparent, if they are to be kept in their most favorable condition.

Mr. Green and Mr. Wilmot both procured eggs this season from the Detroit River. Mr. Green made use of a newly-devised apparatus for hatching, that proved to be a most excellent contrivance, both for the economy of space and the facility for caring for the eggs. By this method he will be enabled to hatch five or six times the quantity of eggs in the same building. The young fishes were distributed in accordance with the excellent plan adopted by the New York commissioners for supplying demands from all parts of the State, without expense, on application.

The success attained by these persevering experiments is now complete, and the white-fish may be restored by artificial propagation, to the same extent as the salmon, or the brook-trout, or the shad. As has been shown, the white-fish has advantages in this particular that the other species have not. The obstruction of streams is no obstacle in the way of their multiplication, because they have no necessity of ascending them, and, unlike the trout and the salmon, they cannot be suspected of eating each other.

Attempts at feeding the young fishes have all been failures, and the only natural food that has been found in their intestines is the species of *Diatomaceæ* reported by Mr. Briggs. But as they are more vigorous and strong in the earlier stages of growth, there is not the same necessity of caring for them until they are partly grown, and they should be put into the waters they are to inhabit soon after the ovisac is absorbed, and allowed to find their natural food for themselves, just as the young shad are treated when hatched artificially.

Artificial propagation affords advantages that compensate for all the overfishing and losses that the fish-faunæ suffer from man and natural causes. The great numbers of eggs found in the ovaries of fishes in reality afford little evidence of their capacity for populating the waters.

It is a fact, illustrated in nearly if not all branches of the animal kingdom, that the most fecund species do not, by any means, increase the fastest in numbers, but from the greater evils they are subject to, and the greater number of enemies they encounter, there is such a fatality during the earlier stages of growth that the losses balance the numbers produced, and less fecund species, by being better protected, equal them in numbers.

The most perfect illustrations of this fact may be found among our lake-fishes. The muskellunge, *Esox nobilior*, has a very large number of eggs. A cast of the ovaries of a large female specimen, made by Dr. E. Sterling, of Cleveland, Ohio, is in the possession of the Smithsonian Institution. The ovaries measure over two feet in length, and the eggs are about the same diameter as those of the white-fish; they contain at least five times as many eggs as a pound white-fish, and yet, as regards numbers, the muskellunge is a comparatively rare fish. There are, undoubtedly, exigencies attending the egg-stage of this fish that will account for this fact.

In the case of the white-fishes, though annually depositing millions

of eggs, the delicate nature of the embryo, and the numerous spawn-eaters, effect a certain balance of numbers with relation to the general faunæ of the lakes, so that, up to the time of the early settlement of the lake-region, the fish were found in great abundance. The nets now came in as an additional agent in preventing the increase, the pound-net, particularly, killing a large percentage of the fishes that had not matured sufficiently to assist the increase by depositing spawn, and in consequence the numbers of fishes were rapidly reduced.

The care of the eggs in the hatching-troughs has proved, beyond question, the frail nature of the eggs of the white-fish. They are smaller, and have a much thinner investing membrane, or shell, and have not the same enduring vitality that the ova of the trout and salmon have. So that in the open water of the lakes and rivers by far the greater number are lost because of the disturbance of the bottom by the autumn storms and the deposit of sediment from the muddy water, the failure of many of the eggs to come in contact with the milt of the male fish, the myriads devoured by the army of spawn-eaters, and the additional evils of pollution of the waters from the drainage of cities, manufactories, and saw-mills, and the dragging of seines over the spawning-beds.

A quantity of white-fish eggs taken from the bottom of the Detroit River, a very extensive spawning-ground, while dredging in company with Mr. George Clark, at the close of the spawning-season, were found to be dead and white, or so coated and stained with the black ooze that they could not have survived. In the pond on Grassy Island, where as many as ten thousand female white-fish deposit their spawn in a season, we succeeded in taking between fifty and sixty embryo fishes, by drawing a seine lined with millinet, and a diligent search through several hours at the surface in the month of April.

In obviating all of these evils, artificial propagation asserts its advantage, and though the number of eggs that may be handled is exceedingly small compared with the millions sown by the fishes, yet the number of fishes produced may really exceed the present production in a state of nature. This assertion has ample proof in the restoration of fishes in regions where they have been nearly exterminated, and even where no change was made in the restrictions upon the fishing that might have assisted the increase.

The experience of the past few years has proved entirely the possibility of increasing the numbers of the white-fish by artificial propagation. The running water in the troughs supplies the conditions required by the eggs; the fertilization of the ova in the pan brings every egg in contact with the milt; they lie undisturbed and free from injurious sediment or filthy water; the spawn-eaters have no access to them whatever, and the dead eggs are immediately removed from contact with the living ones; the young fish are under control in the troughs, until the ovisac is absorbed, when they are ready to be placed in their natural home, the cold waters of the northern lakes.

The experiments of Mr. Seth Green and Mr. N. W. Clark have reduced the loss of the eggs to an inconsiderable number, and with a small outlay of money this fish may be restored with a success equal to that of the shad in the rivers of the Atlantic coast.

The losses in the fry-stage merit consideration, though there is every evidence to believe that they are very small.

One great advantage in favor of the young white-fish is its strength and vigor almost from the time it leaves the egg, and its disposition to seek the surface, as observed in the troughs and where they were seen in their natural condition in Detroit River.

The piscivorous fishes of the lakes are to be found almost entirely in the lesser depths. Of these the pike, *Stizostedion americana*, is the most destructive in the regions where it is to be found in numbers. Their number, however, does not at all approach that of the spawn-eating herring, and it is not probable that the white-fish suffer from their voracity in the earliest stages of their growth, but after they have attained a couple of inches or more in length. The regions where the pike is numerous are the western end of Lake Erie, Saginaw Bay, Lake Huron, and Green Bay, Lake Michigan.

The perch prevails in limited numbers throughout the whole extent of the lakes. The lake-trout is not found, within the range of the smaller white-fishes, in sufficient numbers to do them much damage. The habit of the young embryos to seek the surface is also a protection to them. There is not in the lakes a single surface-feeding fish, except perhaps a few small Cyprinoids and a *Chirostoma*, which are not piscivorous species. There is no savage feeder, such as the blue-fish, *Pomatomus saltatrix*, of the sea, that comes to the surface. So that at this stage of growth they are comparatively safe. There are also large schools of the Cyprinoid family found in the lakes at the same season of the year as the small white-fishes, and from the month of June until late in the fall large schools of embryo fishes are found in the waters, principally Cyprinoids. So that there is abundance at all seasons of the year to supply the appetites of the piscivorous fishes besides the young white-fish, and they, of course, suffer much less in consequence.

The increase of shad on the sea-coast has resulted from turning loose the embryos, when but a few days from the egg, where the piscivorous fishes are numerous, and an increase of equal or greater rapidity may be looked for in the white-fish, with comparatively few dangers to encounter.

(18 *b.*) *Breeding of salmon-trout.*—The breeding of the salmon-trout, *Salmo namaycush*, with the exception of the hatching of a few eggs by Mr. N. W. Clark, has been entirely in the hands of Mr. Seth Green, of Rochester, N. Y. His experiments extend from the fall of 1870 to the present, with continued success. The past season eggs and young of the salmon-trout were distributed to about seventy different persons, to stock the lakes of the State of New York.

F—ECONOMICAL AND NATURAL HISTORY OF THE MORE IMPORTANT FOOD-FISHES OF THE GREAT LAKES.

19.—DISTRIBUTION OF THE SPECIES ACCORDING TO DEPTHS.

(19 *a.*) *Vertebrate fauna.* Observations of the net-fishing at different depths made the fact apparent that there are quite well defined ranges, with reference to depth, in the fauna of the lakes; not that the lines are so distinct that fishes peculiar to a certain zone are not frequently found straying into the ones contiguous, but still so well defined that a fisherman of short experience, knowing the depths at which he is setting his net, can predict with confidence what species of fishes he will capture and what he is not at all likely to take. While a few of the deep-water fishes seldom or never approach the shore, there are many species, of the shallow waters, never taken in deep soundings. The migratory instinct of the spawning-season temporarily changes these habits in a few species, and there is considerable evidence to prove that the temperature of the water modifies the preferences of many fishes to certain depths.

As one or two fishes of the deepest zone are the most constant in their attachment to their limited range, it will be as well to begin with the deeper water, in describing the ranges of the species.

The fishes referred to are, a small Cottoid, the *Triglopsis thompsoni* Gir.; and a Salmonoid, the black-fin, *Argyrosomus nigripinnis* Gill, (Mss.) These fishes are most abundant in seventy fathoms and deeper, and are seldom taken, in the fishing-season, even in as great a depth as fifty fathoms. At Grand Haven, Mich., where a line of steamers keeps the harbor open throughout the winter, the fishermen take the black-fin in quantities, within thirty or forty fathoms, in the month of December. This fish has thus far been found only in Lake Michigan. The *Triglopsis* is only known from specimens taken from the stomachs of larger fishes in Lakes Superior, Michigan, and Ontario. The remaining species, of which a few are sometimes found at the depth of seventy fathoms, are the lawyer, *Lota maculosa* Les., the salmon-trout, *Salmo namaycush* Penn., the siscowet, *Salmo siscowet* Agass., the white-fish, *Coregonus albus* Les., and the cisco, (not the cisco of Lake Ontario,) *Argyrosomus hoyi* Gill, (Mss.)

At fifty fathoms, the nets take the five species last named abundantly. This may be considered, in the deeper lakes, the zone of the Mackinaw trout and of the cisco, throughout the spring, summer, and fall, with the exception, in the case of the trout, of the spawning-season.

Between twenty and forty fathoms the gill-nets take the salmon, or Mackinaw trout, with a few lawyers and ciscos.

From twenty fathoms to the shore are found the most numerous assemblage of species: The lawyer, *Lota maculosa* Les., one or two small Cottoids, *Uranidèa franklini* Agass., and *U. richardsonii* Agass.; the sheepshead, *Haploidonotus grunniens* Raf.; the black-bass, *Micropterus nigricans* Cuv. and Val. and the small-mouthed black-bass, *M. salmoides*

(Lac.) Gill; the rock-bass, *Ambloplites rupestris* (Raf.) Gill; the perch, *Perca flavescens* Cuv.; the wall-eyed pike, *Stizostedion americana*, (Cuv. and Val.;) the sauger, *S. grisea* (DeKay;) the blue-pike, sp. n.; the white-bass, *Roccus chrysops* (Raf.) Gill; four (?) species of Etheostomoids; *Chirostoma sicculum* Cope; the sticklebacks, *Gasterosteus inconstans* Kirt.; *G. nebulosus* Agass., and *G. pygmæus* Agass.; the lake-pike, *Esox lucius* Lin.; the muskellunge, *E. nobilior* Thomps.; the mud-minnow, *Umbra limi* (Kirt.) Gunth; a few Cyprinodonts; *Percopsis guttatus*, Agass.; the white-fish, *Coregonus albus* Les.; the Menominee white-fish, *Coregonus quadrilateralis* Rich.; the lake-herrings, *Argyrosomus clupeiformis* Mitch., and *A. harengus* Rich.; the speckled-trout, *Salmo fontinalis* Mitch.; the moon-eye, *Hyodon tergisus* Les.; the saw-belly, *Pomolobus chrysochloris* Raf.; the mullet-sucker, *Ptychostomus aureolus* (Les.) Agass.; the spotted-sucker, *P. fasciatus* (Les.;) the long-snouted sucker, *C. hudsonius* Les.; the common pink-sided sucker, *Catostomus communis* Les.; the black sucker, *Hylomyzon nigricans* (Les.,) Agass.; the carp, *Carpiodes cyprinus* (Les.,) Gunth., and eighteen (?) species of Cyprinoids; the bull-head, *Amiurus catus*, Lin.; the great lake cat-fish, *Amiurus nigricans* Les.; the fork-tailed cat-fish, *Ictelurus cœrulescens* Raf.; the yellow back-tail, *Noturus flavus* Raf.; the dog-fish, *Amia calva* Lin.; the bill-fish or gar-pike, *Lepidosteus osseus* Lin., and *L. platystomus* Raf.; the sturgeon, *Acipenser rubicundus* Les., and the lamprey, *Petromyzon*. In this zone is also found the Amphibian *Menobranchus lateralis* Say.

It will be observed that the lawyer, the white-fish, and the lake-trout, are found in all depths in more or less abundance. This is a fact, not only in the spawning-season, but at all times. The trout, however, are comparatively rare inside of a depth of about thirty fathoms in the deeper lakes, except during the spawning-season; and the lawyers are only taken in quantities outside of forty fathoms in the spring of the year.

(19 *b.*) *Invertebrate fauna.* The invertebrate fauna of the bottom has been investigated to a limited extent by dredgings.

This work was initiated by the Chicago Academy of Sciences, in the year 1870, in the shallow water off Chicago Harbor. Dr. Stimpson reported finding but little life in this vicinity—insect larvæ, a leech, small mollusks, mosses, and algæ.

Later in the season a tug was employed at Racine, and a party, including Drs. Stimpson, Lapham, Andrews, Hoy, and Mr. E. W. Blatchford, made dredgings in from thirty to sixty-four fathoms, resulting in finding the lake-bottom thickly inhabited by two genera of small crustaceans, *Mysis* and *Gammarus*, a planarian, and a small mollusk, of the genus *Pisidium*. The crustaceans were determined by Dr. Stimpson to be the same as those which Dr. P. R. Hoy had taken from the stomach of the white-fish, in a partially digested state.

In August of 1871, under the direction of General C. B. Comstock, of

the lake survey, Professor S. I. Smith made extensive dredgings in Lake Superior, working out the bottom fauna very thoroughly, and discovering some fourteen new species of invertebrate life, and eleven other forms previously described, distributed from the shores out to one hundred and sixty-nine fathoms in quite well-defined zones.

In September of 1871, on receipt of the notification that the revenue-steamer Andrew Johnson had received instructions to afford facilities for the examination of the fauna of the lake-bottom, a small dredging-outfit was received on board, and as full collections made as the stormy weather of the trip permitted.

The Academy of Sciences of Chicago furnished a large part of the outfit from their stores of apparatus; and Mr. E. W. Blatchford, of Chicago, supplied a quantity of lines and nets, among the rest a trawl-net used by him in collecting off the coast of Florida for the museum of the Chicago Academy. This apparatus, with the dredging-collections of the trip, and the entire collections made on Lake Michigan, was burned, with the academy, in the great fire of that year.

Dr. Stimpson had previously worked up the collection, and identified the species as the same as those of his dredgings.

The trawl-net was used in thirty fathoms in Grand Traverse Bay, but failed to take anything, as there are probably no fishes in the lakes, other than the smaller species, of so little activity as to be unable to escape capture from a twelve-foot trawl.

The dredgings were made in from twenty-six to one hundred and forty-four fathoms. The small forms of life were found to be abundant at all depths, and the bottom fauna was found to be quite uniform in the region of the lake examined. The different dredgings have made it evident that the invertebrate life of the bottom is all small forms, though so abundant as to afford food for unlimited numbers of fishes.

The stomachs of the white-fishes examined in many localities were found gorged with the crustaceans and mollusks which they had found in the bed of the lake.

In the month of August, while making the tour of the northern shores of the lake, in a Mackinaw boat, the dredge was carried over to Torch Lake, in the Grand Traverse region of Michigan. This lake is nearly eighteen miles long, with an average width of two miles. Its outlet is first through a shallow creek, then through two connecting lakes, and through a sharp and shallow rapid into the bay. Earlier in the season, with a roughly-prepared map in hand, I had sounded the lake through about eleven miles of its length, to determine its average depth, which was found to be forty fathoms, the deepest soundings being forty-five fathoms.

The hauls of the dredge discovered the same species of invertebrates found in Lake Michigan. The fishes of Torch Lake are also the same as in the main lake, its transparent waters harboring none of the properly river or stream fishes.

The deep trough of Torch Lake is the eastern one of a series, with a general north and south direction, easily traceable in the United States Army engineers' chart of the north end of Lake Michigan, which forms a notable feature in the submarine topography of the lake.

Two other lakes in Michigan, in which the white-fish are said to make their home, are Crystal Lake, near Frankfort, and Higgins Lake, in Roscommon County. There are also a few small lakes into which they have been introduced.

L. J. Farwell, ex-governor of Wisconsin, introduced the white-fish into the lakes at Madison, in the year 1850.

20.—The salmon or Mackinaw trout, *Salmo namaycush* Penn.

The trout of the great lakes is one of the three most numerous fishes, and, except the sturgeon, attains the greatest weight of any of the lake-fishes. It is captured almost exclusively by the gill-nets, the pound-nets in some portions of the lakes taking them during the spawning-season. In winter a great many are caught in the bays, through holes cut in the ice. They are found in all of the great lakes and in a few inland lakes in their vicinity.

As compared with the white-fish, their merits as a fresh fish are relative to taste, though the greater number would decide in favor of the latter. Salted trout bring a lower price in the market than white-fish, as they are inferior to them as a salt fish.

Their migrations, as far as observations have been made, are confined to the spawning-season. They do not ascend the rivers, and although they are known to be in a few inland lakes connected to the main lake by rapids, there seems to be no knowledge of their ever having been seen or taken in the outlets.

Their range of depths at other seasons than the spawning-period is in deep water. A few stragglers occasionally approach the shore, and are taken in the pound-nets, or with the hook, from the piers extending into the lake. In the northern portions of Lake Michigan they are taken in depths of fifteen fathoms, in small numbers, by the gill-nets, and more plentifully through the ice in the winter time, though a depth of over thirty fathoms is the most favorable ground for their capture.

In the shallow waters of Lake Erie, in the western part of the lake, they are scarcely found at all, though numerous in the deeper portion, east of the city of Cleveland.

The lake-trout is a ravenous feeder. The fishermen say of him that "he always bites best when he is the fullest."

In Lake Michigan, where the investigation of the character of their food was carefully made, it was found to be principally the cisco, *Argyrosomus hoyi* Gill. Mss. The prevailing notion that they feed largely upon the white-fish was not confirmed by these observations. Although it was continually asserted by the fishermen that the stomachs of the trout were found full of young white-fish, there was no instance under my

observation where it was so. During 1871 no opportunities were omitted to observe the stomach-contents of the trout, when they were sufficiently undigested to determine the species, and often, when, to confirm the repeated assertions, a fisherman would throw out the contents of a stomach, to show me the young white-fish, the head and mouth invariably indicated the genus *Argyrosomus* Agass., and he would readily admit his mistake.

Questioning fishermen closely, who asserted that they found the young white-fish to be the principal food of the trout, they generally assented that they had not given close enough attention to decide positively between young white-fish and the cisco, though many gave testimony of finding unmistakable white-fish, of mature size, in the stomachs of the overgrown trout taken in portions of the lakes.

Stragglers into the shoal waters, and the trout migrating into shallow places, to find their spawning-grounds, would undoubtedly prey upon the smaller white-fish as readily as they would upon any other species; but during the larger part of the year they make their home in deeper water than the young fish are found in.

An instance was related, in 1871, of a large trout having swallowed a smaller one, which the fisherman removed from its stomach in a good state of preservation.

It is not an unusual thing for a trout to swallow a fish too large for the capacity of his stomach, and the tail protrudes from his mouth until the forward part is digested. A trout measuring twenty-three and one-half inches was brought ashore at Two Rivers, Wisconsin, from the mouth of which some three inches of the tail of a fish, *Lota maculosa*, projected. The "lawyer," when taken from the trout, measured fourteen inches without the head, which had been digested.

Their exceeding voracity induces them to fill their maws with singular articles of food in the bill of fare of a fish. Where the steamers or vessels pass, the refuse from the table is eagerly seized upon, and I have taken from the stomach a raw peeled potato and a piece of sliced liver, and it is not unusual to find pieces of corn-cobs, in the green-corn season, and in one instance I heard of a fragment of a ham-bone.

They are readily taken with a hook baited with pieces of fish. They are a sluggish fish to pull in, taking hold of the bait with a tug at the line and then allowing themselves to be pulled to the surface, with no more vibration in the line than if a heavy sinker was the weight at the end. Parties going out with the fishermen often take a large number while the nets are being lifted, and in some localities the largest of the trout are taken in this way. While becalmed near Summer Island, in Lake Michigan, in 1871, two of us, in about one hour's time, took in fifty pounds of trout, in seventeen fathoms of water.

The explanation that the red color of the flesh of certain species of this family is attributable to the red pigments of crustaceans, which form a principal article of food, is very directly contradicted in the ex-

ample of the Mackinaw trout and the white-fish. In this trout the very deepest tints found in the flesh of the salmon are frequently to be seen, while the food of the trout is almost wholly fishes, and in no case crustaceans; while in the white-fish the flesh is of the purest white, and the food is almost wholly crustaceans, and largely of *Gammaridae*, with a considerable amount of the red pigments referred to in their shells.

The spawning-season of the trout begins about a month earlier than that of the white-fish. The details of their habits I can only give from information I have gathered by continually questioning fishermen and others who have had better opportunities of observing them than I have. The universal testimony is that the spawn is found running from the females in the latter part of the month of October, the fish coming on to the spawning-ground a week or more earlier.

At Detour, at the head of Lake Huron, on the 16th October, I saw a large lift of trout brought in from the spawning-grounds; the ova were large and separated, but were still entirely retained in the folds of the ovaries, and the fishermen said they had not found them running from this fish as yet.

The localities selected by the trout for their spawning-ground are usually rock bottoms in from fifteen fathoms to seven feet of depth. Near Milwaukee, on a reef at about the greater depth named, is a spawning-ground, from which for years a large type of trout has been taken. The spawning-grounds are found from Racine north on the western shore of Lake Michigan, and from a little to the northward of Saint Joseph north on the eastern shore. The spawning-ground nearest Saint Joseph is said to be a clay bottom. At Detour the nets were set so close to the shore that the tips of the floats showed above water.

The trout are said to settle close to the projections and edges of the honey-combed cavities of the rock, and that, frequently, when a loose fragment of the rock is drawn up by the nets, the cells are found to contain numbers of the eggs.

The ovaries from a Mackinaw trout of twenty-four pounds weight were preserved, and weighed three pounds four and one-fourth ounces, and contained fourteen thousand nine hundred and forty-three eggs; the calculation being made by counting a fractional weight.

The knowledge of the time at which the young fish make their appearance is limited to the experience of the few fish-culturists in the country who have hatched the eggs. In water of an average temperature of 47°, they are found to hatch about the last week of January. At the lower temperatures of the water, in a state of nature, their development would be retarded for several weeks.

Of the habits of the young trout I am entirely destitute of information. I have seen one of eight inches in length, and learn of rare instances in which the fishermen have seen small ones. The smallest ones

that are taken in any numbers are fifteen to eighteen inches in length, and these are not very numerous.

The average weight of the lake-trout taken in the gill-nets is nearly five pounds. It is claimed that in years past they averaged much higher. They are quite frequently taken weighing fifteen pounds. A specimen of a female was obtained last summer at Shoal Island, Lake Superior, weighing twenty-four pounds. One taken at Grand Haven, Mich., in the month of June, 1871, a female, weighed thirty-six pounds and one-half. After the gills and entrails were removed, it weighed twenty-nine pounds. It measured three feet six and one-half inches in length.

The tradition of the largest trout taken is preserved at each locality, ranging from fifty to ninety pounds. One that I am satisfied was authentic, from having taken the testimony of those who saw it weighed, and having the story confirmed by Father Peret, of Mackinaw, was taken at that place in 1870, and weighed eighty pounds.

There are no species of fishes in the lakes sufficiently formidable to be considered enemies of the trout after they mature. The spawn and fry probably suffer to some extent from the same causes that the ova and young white-fish do.

They are troubled with a few parasites, especially a tape-worm that is found very numerous in the intestines of some of them. Solitary individuals, known among the fishermen as "racers," are found in the summer-time swimming sluggishly at the surface. They are easily taken with the gaff-hook, and bite readily at any bait thrown to them. They are always very thin in flesh. Dissection of the few that I have taken failed to find any adequate cause for their condition. The parasites were generally present, but not in any larger number than in healthy fish.

The fishermen on the north shore of Lake Michigan generally keep a few hogs. The offal of the white-fish is fed to them freely, but they are very careful to allow no trout-offal to be thrown in their way, asserting that the hogs, after eating trout, frequently become crazy and die. The only plausible explanation of this fact, if it is a fact, is that some entozoon of the Mackinaw trout, passes through one stage of its development in the hog, and occasions disturbance of the brain, having much the same habit as the cystic *Cœnurus* does in the sheep.

Dr. Bannister informs me that the opinion prevailed among some of the Russian residents of Alaska that a tape-worm was occasionally produced in the human subject by eating the *chaiwicha*, *Salmo orientalis* Pal., the largest species of salmon common in that country. The fact that it was quite a common practice to eat fish frozen, or dried, or salted, without cooking, would favor the introduction of any parasite existing in the body of the fish.

The decrease in lake-trout is not so apparent as it is in the white-fish. The pound-nets have not made the extensive inroads upon their numbers,

and none but mature fishes are taken. The larger ones are less numerous; and it is claimed that the average weight of the trout caught is less than in former years.

Like the other Salmonoids, the trout have proved to be well adapted to artificial culture. The one drawback with them is the difficulty of obtaining the spawn in the fall of the year, when the rough weather renders the visits to the spawning-grounds a matter of hardship and danger.

21.—The Siscowet, *Salmo siscowet* Agass.

This interesting fish is confined, so far as known, to Lake Superior alone. In a few localities in that lake it is very numerous.

With rare exceptions of young specimens, found near the shore, it is taken entirely with the gill-nets in deep water. It is a remarkably fat fish, and, as a fresh fish, is very inferior for the table. Even boiled, it is oily and rank in flavor. As a salt fish, packed in brine, it is most excellent, and is universally admitted to surpass either white-fish or trout. Its range of depth is outside of forty fathoms. How much deeper than this it may be found I cannot tell, as no fishing at greater depth than fifty fathoms came under my observation in Lake Superior. The stomachs were found to be filled with a Cottoid. This seemed to be its entire article of food in the vicinity of the Apostle Islands.

The flesh varied from nearly white to a light reddish tint, not so deep-colored as is found in the salmon and the Mackinaw trout.

They spawn earlier in the fall than any of the other Salmonoids in the lakes. By the latter part of August the spawn in some of them is ripe and running freely, while in the month of September the females are all ripe and depositing spawn. They seemed to have no migratory instinct at this season, but were taken while spawning in the same vicinity where they had been taken for weeks previously.

The ovaries from three specimens of mature females contained the following quantities of eggs:

Weight of fish.	Weight of ovaries.	Number of eggs.
	Ounces.	2,796
5 pounds	12	3,120
5 pounds	10	3,756
	12	

We have no knowledge of the time it requires the eggs to hatch, nor any data with reference to the growth of the fish. The young ones probably remain in deep water, as they are not taken in the pound-nets, and frequently quite small ones are found in the gill-nets. They will average about four and one-half pounds in weight, the largest coming under our observation weighing about eight pounds.

The enemies with which they would have to contend are probably few. The white-fish lives in the vicinity of their spawning-beds, and as it is known to be a spawn-eater, it probably makes food to some extent of the eggs of the siscowet, though in the early days of September, when we had opportunity to examine the white-fishs' stomachs, no eggs were noticed. The food of the Cottoid we were unable to learn, as the only specimens we obtained were from the stomachs of the siscowet, and nearly digested. It is quite possible the eggs form part of its food.

One external parasite was found to be numerous, a Lernean, and the intestines were generally infested with tape-worms in abundance.

22.—The white-fish, *Coregonus albus*, Les.

(22 *a.*) *General considerations.*—The species of the genus *Coregonus* are widely distributed through all the northern regions of both hemispheres, from about 46° latitude in the Old World and 41° 30′ in America, to the Arctic seas. They are the most extensively used of all fresh-water food-fishes, unless it be the carp of China or the genus *Salmo*.

They inhabit all the deeper lakes in the regions referred to, the rivers of the more northern latitudes, and some of the species, if not anadromous, live indifferently in either the rivers or the sea. Specimens from Hudson's Bay are in the possession of the Smithsonian Institution, and in Pallas's *Zoographia Rosso-Asiatica* several species of the *Coregoni* are described as ascending the rivers from the sea. They have been a most extensive food-resource to the Indians, pioneers, trappers, and hunters of the vicinity of the great lakes, and throughout British America and Alaska. The statistics already given indicate the extent of their use in the older and more thickly populated region of the country.

The white-fish has been known since the time of the earliest explorers as pre-eminently a fine-flavored fish. In fact there are few table-fishes its equal. The testimony of very many summer travelers, this season, on Lake Superior, from Eastern States gave preference to the white-fish over the shad, both for flavor and its almost entire freedom from bones. To be appreciated in its fullest excellence, it should be taken fresh from the lake and broiled. Father Marquette, Charlevoix, Sir John Richardson, explorers who for months at a time had to depend on the white-fish for their staple article of food, bore testimony in their writings to the fact that they never lost their relish for it, and deemed it a special excellence that the appetite never became cloyed with it.

The fact that the white-fish is loth to take the hook is sufficient to prevent much interest in it from a large class of people. There is danger, in the work of fish-culture in this country, of conceding too much importance to this point in the habits of a fish. The fish-interest of the country has a much larger stake in the protection and increase of the staple-food fishes than in the game-fishes simply as such; although it might readily be acknowledged that among all other sporting recreations angling was the most sensible. Seth Green, in his magnificent

success in restocking the rivers of the Atlantic slope with the shad, did a work of far greater importance than he with other fish-culturists have done in the propagation of trout.

The cod, mackerel, herring, white-fish, shad, salmon, and salmon-trout, deserve the principal attention in the efforts at increase.

With the three first-mentioned artificial propagation has nothing to do at present; probably never will. Of the others the white-fish is the most important as a food-resource, because of its numbers and because it can be obtained at all seasons of the year.

In adaptability to artificial propagation it is probable the shad has the advantage because of the rapid development of the eggs. But there is still a difficulty in the way of the propagation of an unlimited number of shad, in the fact that the streams to which they formerly resorted are obstructed by numerous and high dams. There are no obstructions of this character to interfere with the white-fish; and in the great lakes, if it were advisable, there is nothing apparent in the way of the propagation of unlimited millions.

The character of its food has also a bearing on its adaptability to rapid increase. There is considerable loss among the speckled trout from the larger ones preying upon the smaller. In England the salmon have been accused of the same habit to some extent, while the young are in the parr and smolt stage. But nothing of this kind will ever deplete the numbers of the white-fish. Invertebrate forms of life constitute its entire food. To some extent it will suffer from the rapacity of other fishes, but, as shown on other pages of this report, in a state of nature the ova-stage is the one in which the greatest loss is suffered.

(22 *b.*) *The food of the white-fish.*—The food of the white-fish has been a problem inciting numerous conjectures among fishermen, sportsmen, and fish-culturists, and baffling the investigations of a few naturalists for a number of years past.

To Dr. P. R. Hoy, of Racine, we think belongs the credit of first discovering correctly the character of their food. On opening the stomachs of numerous white-fish he at first failed to determine the character of the stomach-contents, until, after washing the half-digested mass in a basin of water, he found the sediment to be full of small *Crustacea*, whose existence in the lake had never before been suspected.

My examination and preservation of the stomach-contents from all quarters of the lakes confirmed Dr. Hoy's observations, and discovered a few other small forms of life as the food of white-fish.

The invertebrates found were of crustaceans: species of the families *Gammaridæ* and *Mysidæ;* of the mollusks: species of the genus *Pisidium;* and certain insect larvæ.

A few fish-ova were frequently found in the stomach, and it was not unusual to find a little gravel.

In the greater portion of the lake the *Gammaridæ* constituted the principal food. In shallow regions small *Conchifers* were more nu-

merous. At Point aux Barques on the north shore of Lake Michigan, where a very large type of the white-fish was found, the stomach-contents were entirely of the *Mysis relicta* Loven. In the Sault Sainte Marie Rapids in July a mass of small Chrysalides was found in the stomachs of a number of white-fish. In October, from the same locality, the larvæ of the caddis-fly were found in the stomachs, apparently carefully separated from their artificial coverings. Stomachs opened in Lake Superior contained principally the *Mysidæ*.

At Rocky Island, in the northwestern part of Lake Michigan, a vessel with a cargo of wheat was lost a few years ago. The fishermen say that white-fish were taken in that vicinity for several years afterward with wheat in their stomachs.

Rarely white-fish will take a bait. The breakwater protecting the Illinois Central Railway at Chicago was formerly a favorite fishing-place, and in early summer was often lined with a row of boys and men fishing for perch. There was seldom a day passed but that a few white-fish were taken. Mr. Trompe, of Sault Sainte Marie, has frequently taken them in that locality with a hook baited with a May-fly, *Ephemeridæ*. At a fishing-dock on Sand Island, one of the group of the Apostle Islands, Lake Superior, there were a few taken this season with a worm-bait.

The leech, *Icthyobdella punctata* Smith, parasitic on the white-fish, and numerous in some localities, was in no instance found in the stomach. This corroborates Dr. Hoy's observations.

A similar fact was noticed afterward at Detroit River. A parasitic crustacean, a *Lernæa*, was found adhering to the white-fish in numbers, and, though many stomachs were examined, in no instance were any of the parasites found in the contents.

Both the *Lernæa* and the *Icthyobdella* are related to species made use of as food by the white-fish as near in the one instance, as being in the same class, and the other in the same order.

The mouth is constructed for nibbling along the bottom, the opening being directed nearly downward, and they gather in the small life of the bottom and the gravel as they move slowly along.

Dredging in the lake at different localities and examination of stomach-contents at numerous points prove that the crustaceans and the mollusk, constituting the principal food of the white-fish, are distributed throughout the lake-bottom, in all localities and at all depths, over about twenty fathoms.

In Torch Lake, a deep inland lake in the Grand Traverse region, Michigan, where a large type of white-fish is found, the dredge brought up the same species of crustaceans and mollusks as were found in Lake Michigan.

The failure to find food in the stomachs of white-fish has frequently resulted from the fact that the fish examined were taken from the pound-nets, where they had remained long enough to digest the contents of the

stomach before they were taken from the water. Fish from the gill-nets have generally the food in the stomach only partially digested, while a hundred fish in succession from the pound-nets may be opened and every stomach found empty.

It is frequently asserted that aquatic vegetation afforded sustenance to the white-fish. The investigations in the past two years did not result in any confirmation of this notion, and it would not accord with the habits of any species of the family of fishes to which the lake white-fish belongs.

(22 *c.*) *The migrations of the white-fish.*—The assertion was sometimes made among the fishermen that the scarcity of white-fish at any one locality was no reliable indication that the number had decreased, but that the schools had probably migrated to some other region.

At Waukegan, Ills., the white-fish come into shallow water in the greatest abundance in the months of June and July. The same habit is observed in various localities on the lakes, though by no means at all points. Several places on the shores of Lake Michigan, in the south half of the lake, in the vicinity of the Apostle Islands, Lake Superior, and at the Thunder Bay Islands of Lake Huron may be referred to as localities where the July migration occurs. George Keith, Esq., a factor of the Hudson Bay Company, at Michipicoten, in 1840, affords Sir John Richardson the same information in the habits of a species of the *Coregonus*. It was for a long time a difficult matter to discover the reason for this summer run on the shore, if, indeed, it has yet been correctly accounted for. The contents of the stomach were found to be the same as at other seasons of the year. It was not probable that the white-fish was an exception to all its congeners of the Salmonoid family, and preferred the warmer temperature of shallow water to the colder waters outside. Besides, the schools of white-fish were always found to leave a region where wide areas of shoal-water existed as the heat of summer advanced. The theory adopted to account for this summer visit to the shore was that the calm, quiet weather of the summer months, from the slight disturbance of the surface, prevented the amount of aeration to the water that occurred at other seasons of the year, and the fish sought the shore where the splashing on the beach and sand-bars supplied the water with the requisite amount of air, just as other species of this family of fishes delight in rapids and falls, because the breaking up of the masses of water supplies it with a large amount of respiratory gases.

In waters like Lake Erie, where, according to the lake-survey, the temperature attains as high as 75°, the white-fish seek the cooler deep waters in the summer, and I have not learned of a migration upon the shore at any point, they, perhaps, preferring a less amount of aeration to a high degree of heat.

The fact that in the month of August the white-fish of the Sault Ste. Marie Rapids leave the river entirely, and do not return until in Septem-

ber, weakens the force of the theory that the aeration of the water is the necessity that brings them to the shore of the lake in the summer.

Professor Agassiz, in his tour of the north shore of Lake Superior, in 1849, found the white-fish scarce along the shore and at the rapids, in the month of August. Among the Apostle Islands, Lake Superior, and n most of the deeper portions of the lakes, no scarcity is observed at this season of the year. At the rapids they so entirely abandon the locality in August that the supply of fish for the hotels has to be obtained from Point Detour, at the head of Lake Huron.

It was a disputed point among the Waukegan fishermen whether the migration was directly in from deep water or along the shore. The fact that, in some instances, the schools of fish struck the nets at one point, and afterwards entered the nets in succession along the line of the shore, was thought by many to prove a littoral migration. But the fact was that, in all likelihood, the advance portion of a school would touch the shore at some point and then move in either direction along its line.

The presence of large white-fishes in numbers at certain localities on the north shore of Lake Michigan, of a size that are never taken at other parts of the lake, would indicate a local habit, with no disposition to range through long distances.

Another observation, sustaining the probability of this, is the fact that there are many localities on the lakes where the pound-nets, a few years ago, found prosperous fishing, and in the first few years took the white fish in great abundance, but found afterwards a decrease from year to year until the locality was abandoned, while fifty miles away the business still continued successful.

The well-known local instincts of the salmon would, to a slight extent, confirm the probability of like instincts in its related genera.

The fact that certain types of the white-fish are peculiar to particular localities, as the north shore of Lake Michigan, the Sault Ste. Marie Rapids, Bachewauna Bay, on Lake Superior, indicates a local habit through many generations until certain characters of a race have become established. The same fact has been stated for the shad on the Atlantic coasts.

Some observations made in 1871, perhaps indicate the opposite of all the foregoing statements.

In the early part of the season there had been very few fish caught on the west shore of Lake Michigan, between Chicago and the Door Islands. South of Chicago, at the mouth of Calumet River, the run of white-fish was in excess of anything had for years. But, about the 15th of June, the schools of fish left Calumet, and a few days later there was a decided improvement in the catch at Evanston. About June 22, the lifts at Waukegan began to be heavier than they had been before. During the first week of July the fishing was observed to improve at Milwaukee, Manitowoc, and Bailey's Harbor, and, a little later, at the Door Islands.

The coincidence in dates rather indicated a probability that the same schools of fish that clogged the nets at Calumet during six or seven weeks had ranged northward along two hundred and sixty miles of coast. Still, the effect on the fishing would have been the same if it had been the migrations of schools of fish from deep water at these points in to the shore.

In order to obtain a definite knowledge of their habits in this particular, metal tags, with numbers indicating the locality, were distributed to fishermen at twenty points along the lake, to be fastened to the fins of live fish, which were then to be released. Instructions were at the same time sent to all fishermen to report the capture of fish bearing these marks, and the distances from where they were taken to the point of departure would indicate the extent of their migrations. It is thought that but few of them were used. A similar proceeding was afterward carried out by Mr. George Clark, of Ecorse, on the Detroit River, but none of the fish were ever heard from.

Some of the fishermen of the west shore assert that, after severe storms, encroaching on the shore, and making the water muddy for a long distance out, when the storm subsides there is a heavy deposit of mud on the bottom, and that the white-fish abandon the locality for a time, because, as they surmise, their food is buried in the sediment. On the contrary, after ordinary storms, there is generally an improvement in the catch of fish, probably for the reason that the great aeration of the water renders them lively, and incites them to move about.

The migration from the southern portion of Lake Michigan is of yearly occurrence, about the middle of June, and is, without doubt, occasioned by the large extent of shoal water becoming heated. The same thing occurs in Green Bay, and in the shoal regions of the western end of Lake Erie.

The migrations into shallow water, and up certain streams, in the fall of the year, for the purpose of spawning, will be considered further on. This migration, and the summer visit to the shore, are the general migrations peculiar to the white-fish, while the departure from shoal regions in summer, and from certain localities in August, are local peculiarities.

(22 *d.*) *The habits of the white-fish during the spawning-season.*—The anadromous habit of the salmon is shared by their relatives, the *Coregoni*, to a considerable extent. Several species are known to ascend the rivers of Northern Asia and Europe, from the Arctic Sea. These migrations, as described by Pallas, though they have not, perhaps, in all species, a close relation to the time of spawning, in a few are quite evidently for that special purpose, as, in his *Salmo clupeoides*, *Coregonus merkii* of Gunther, he says they ascend the rivers during the autumn, and return again when the ice forms.

Others live indifferently in fresh and salt water. There are specimens, in the National Museum, of white-fish collected by the late Mr. Drexler, from Hudson's Bay. Some eight or nine species of the Arctic regions

are found in both salt and fresh water. The *Coregonus quadrilateralis* Rich., of Lakes Superior, Michigan, and Huron, was found by Richardson in the Arctic Ocean.

The white-fishes, throughout the larger portion of the lakes, come into shallow water, to deposit their spawn, about the middle of November, just at the time when the salmon-trout has finished spawning and is returning to deep water. At this season they come in from deeper water, in vast schools, and are taken in large quantities by the nets. A notion, prevalent among the fishermen in some localities, that the female fishes arrived first, and were followed, a few days later, by the male, was not confirmed by my observation.

The bottoms on the spawning-grounds vary in character in different localities; rock, sand, clay, and mud being used indifferently for the spawning-beds.

The depths at which they spawn range from eight feet to fifteen fathoms; the larger number probably spawning in depths of about eight or ten fathoms.

In the Sault Ste. Marie River, and in the Detroit River, in the fall of the year, they congregate in great numbers, for the purpose of spawning. In a number of rivers emptying into Green Bay, the white-fish was formerly taken in abundance, in the spawning-season. Saw-mills are numerous on all of these streams at the present day, and the great quantity of sawdust in the streams is offensive to the fish, and has caused them to abandon them. In one or two rivers of the north shore of Lake Michigan they are still found in the autumn.

The Michipicoten River of Lake Superior, on the authority of Major Long, who commanded an expedition to this region in 1823, and George Barnston, Esq., of Montreal, Canada, formerly of the Hudson Bay Company, is a favorite spawning-ground of the white-fish. The Nepigon River, which our steamer entered while returning from the north shore of Lake Superior, about the middle of October, was said to contain schools of white-fish, which had probably entered the river for the purpose of spawning.

There is a probability that there was a time when the white-fish ascended many of the clear rivers of the northern lakes, though that this was a universal habit is not probable, at any rate since the white man has been in the country.

The fishermen, with their gill-nets, follow in shore the migration of the white-fish in the month of October, and a few days before the middle of November the spawn is ripe in a few fishes, and by the middle of the month is running freely, so that boats and nets are covered with the spawn and milt. Just at the time the ova are beginning to ripen the lake-trout, *Salmo namaycush*, has finished spawning, and is leaving for deep water. The white-fish continue to spawn until the last week of November or the first week of December, when they, too, leave the shore and seek deeper water.

In the Detroit River, where there were fine opportunities for observing the fish at this period, owing to the advantages afforded by Mr. George Clark, of Ecorse, we found that the fish ascended the river about the last week of September, usually following the same course among the islands year after year. Mr. Clark's observations on the migration of the white-fishes had discovered that they ascended much farther years ago than they do now. They are still taken as high up as Cottrelville, twelve miles up the Saint Clair River. None have been caught above this point for many years. It is a singular fact that the white-fish are not known to descend from Lake Huron into the Saint Clair River. This is established by abundant evidence from continued fishing at Fort Gratiot, where Mr. Clark, between the years 1830 and 1842, took large quantities of the wall-eyed pike, *Stigiostedion americana*, taking frequently one thousand barrels in a year. The catch of white-fish amounted to an occasional supply for his own table, except after long-continued storms from the northward, when the fish sometimes entered the river in schools. They were never found in this portion of the river in the spawning-season.

The same fact is claimed by the Indians in the Sault Sainte Marie River, that the white-fishes of the lake above never descend the rapids, while the white fishes of the river, it is also asserted, never ascend to Lake Superior. There is not as good evidence for the truth in this locality as at Fort Gratiot; still it may be the case.

Examining the fish on the 30th of October, it was found that the spawn of the white-fish was hard and firm, with rarely a fish approaching ripeness.

On the 1st of November, in the picketed pond, where the fishes are inclosed, numbers of fish were seen jumping from the water, principally the herring, who take delight in this exercise at different seasons of the year. Occasionally a white-fish threw its bulkier form above the surface.

On the 8th of the month Mr. Clark and I were out on the piling surrounding the pond, and found the white-fish jumping in numbers, so that there was a continual splashing of the water. They almost uniformly jumped in pairs, and we could see quantities of spawn in the water immediately afterwards, which rapidly sank.

Mr. Clark and I both succeeded in capturing a pair in the act of leaving the water, and found male and female with milt and spawn running freely. Mr. Clark made use of a fine wire scoop as the pairs of fish disappeared from the surface, and almost invariably took a quantity of spawn from the water.

The males were uniformly smaller than the females. I succeeded in catching a pair in which the female weighed seven pounds, and the male, who escaped before he was weighed, did not exceed one and a half pounds.

November 9.—I again saw the white-fish jumping from the water in the evening, almost uniformly in pairs. Rarely there were three leaped

together, one female and two males. In the pairs there was always a large one, evidently a gravid female, and a smaller one, the male.

At this season of the year it is easy to detect the difference in sex, the abdomen of the female being swollen and rounded, while the males are leaner and angular in the abdominal lines.

I saw by long watching that the males were worrying the females. They seemed possessed of strong sexual ardor, and followed the female with persistence, keeping close against her and with the head about even with the pectoral fin. Driven by the persistent attention of the male the female arose vertically, he following, and she making a convulsive effort to escape, the water being from three to ten feet deep, they threw themselves together above the surface, and the spawn and milt were emitted at the time when, from their position, their vents were approximated. The spasmodic fluttering and effort observed suggested a sexual orgasm. At times I saw them moving rapidly beneath the water in the same close contact, and the male with his snout even with the pectoral fin of the female, often turning together with the white of the belly upward as she turned and twisted to escape him. Often as they came out of the water they would fall apart in different directions, but the male invariably turned immediately in pursuit, so that I was led to think they were monogamous, as is the fact with their relatives the salmon and the speckled trout.

November 10.—The white-fish jumping in great numbers toward sunset. In most instances, when near by, I observed a quantity of eggs, perhaps three hundred or five hundred, emitted at once. The milt of the male did not discolor the water.

The same actions occurred as before observed, springing vertically from the water with a spasmodic, fluttering effort, the male's head opposite the pectoral fin of the female, turning together beneath the water until both abdomens showed upwards. Occasionally three sprang above the surface together. Sometimes the pair fluttered along the surface together for a long distance.

November 14 *and* 15.—Went out to the pond at midnight, and again at 1 o'clock a. m., and found the white-fish jumping. The fact that they are quiet in the day-time, previous to 4 or 5 o'clock in the afternoon, indicates a parallel habit to that observed by Seth Green, of New York, in the shad, they, as he asserts, spawning principally in the night, though, unlike what was the case with the shad, we had no difficulty in finding spawners in the forenoon with the seine.

November 18.—The fishing stopped all along the river. Visited the island. Cold, strong wind from the southwest. Thermometer 26°. No white-fish to be seen in the pond. A few herring coursing around the piling.

November 19.—Same as yesterday; no white-fish to be seen. Caught some of the herring with the dip-net; found their spawn still hard and small; their stomachs were full of white-fish spawn. Mr. Clark and I

took a boat with two men and dredged in the river, obtaining a quantity of white-fish eggs. Nearly all were dead. Afterwards dipped a quantity from the pond, nearly all of which were dead.

November 20.—Made another visit to the island. No white-fish seen in the pond. Cold, freezing weather.

On the 24th and 25th of the month, while at Sandusky, Ohio, numbers of white-fish were found with the spawn in different stages of ripeness, though a majority of them had spawned.

After spawning, the abdomen of the female fish is somewhat flabby and wrinkled, and the fish is undoubtedly relaxed and weak; but not to the extent that the salmon, as well as certain other species of the *Coregoni*, are said to be reduced. The male shows but little indication of weakness.

A series of ovaries were preserved from fishes of different sizes, and a count made by weighing the entire ovaries and then counting the eggs of a definite fraction, and calculating from it the number of the whole. Accurate scales were used for this work, and the table may be relied upon as correct:

Weight of fish.	Weight of ovaries.	Number of eggs.
	Ounces.	
2 pounds	5¾	21,229
2¾ pounds	7½	28,500
4 pounds	16	48,000
7½ pounds	25	66,606

This makes an average of about ten thousand increase for every additional pound weight in the fish, which is precisely Mr. Seth Green's estimate, from his observations in spawning white-fish. Considerable variation in the weight of an equal number of eggs was observed, depending upon the stage of development at which they had arrived in the ovaries.

During the spawning-season, the fish from the river were found to have very little in their stomachs.

(22 *e.*) *Habits of brook-trout during the breeding-season as compared with those of the white-fish.*

A comparison of the habits of the male and female white-fish with those of the trout, *Salmo fontinalis*, and of the salmon, is interesting, from the entire difference of their conduct toward each other, and the manner of depositing the spawn.

The male brook-trout, in his behavior to his mate, is a cavalier of the first order. His colors are at their brightest, and his fresh and bright appearance makes him one of the handsomest inhabitants of the northern waters. Instead of driving the female and annoying her with a persistent worrying, as is the case with the white-fish, his whole wooing is

the most polite attention and the gentlest of persuasions. He moves continually to and fro before her, parading his bright colors, while she rests quietly, with her head up-stream, vibrating her fins just sufficiently to prevent floating down.

While at Mr. H. F. Dousman's breeding-house, near Waterville, Wis., early in the winter, I had the opportunity of observing the habits of the trout on their spawning-grounds. A pair of large trout had selected a spot near the bank of the stream where the water was about ten inches deep. The female had fanned the gravel with her tail and anal fin until it was clean and white, and had succeeded, by strong sweeps and flappings of her caudal fin against the bottom, in excavating a cavity in the bed of gravel.

December 14.—A pair of large trout were frightened away from their nest as I came to the edge of the bank. Concealing myself behind a willow-bush I watched their movements. The male returned first, reconnoitering the vicinity, and satisfying himself that the coast was clear, spent a half-hour in endeavoring to coax the female to enter the nest. She, resting half concealed in the weeds a few feet away, seemed unwilling to be convinced that the danger was gone, and he, in his full bright colors, sailed backward and forward from the nest to his mate, rubbing himself against her, and swimming off again in a wide circle close along the bank, as if to show her how far he could venture without finding danger. She finally entered the nest.

December 15.—Carried out a buffalo-robe and shawl to the top of the flume, near the head spring. Found a pair of trout in possession of a nest. They fled at sight of me, and having got comfortably settled in the robes, I lay quietly for fifteen minutes before the male approached. He swam directly over the nest, and examined in the vicinity for a few seconds, and then swam off to find his mate. A close observation detected a scar on his side, possibly received in a battle with some other male. It served as a very distinct mark to identify him among others. He returned to the spot once, driving off another male before she came with him. They moved along in the vicinity of the nest, she turning and swimming away for a short distance once or twice, and he attending her devotedly. She finally settled in a nest about five feet from my position. He drove away a small trout several times without any very violent demonstrations. She soon began to turn in the nest as if examining its condition, and again settled quietly, keeping up the slow fanning movement with her tail, the anal fin brushing the pebbles as large as pigeon-eggs that were in the cavity.

Soon after she rolled on her side, made three convulsive flutters, striking the pebbles with her tail, and sending up a little cloud of gravel and sand. Immediately afterward she turned short round, as if looking at the condition of the nest, or its contents, and once I thought I detected her in taking some gravel, possibly an egg, in her mouth. She lay resting quietly on the bottom for a short time, while the male played

back and forth around her. She moved away from the nest after a while, visiting some nests in the vicinity that probably contained the eggs of other trout, but soon returned to her own nest. The male attended her very closely, and, as they returned to the nest, resting for a second near her, he curved his body slightly, bent the dorsal fin to one side, and with his body strained to rigidity, a slight tremor was observed, and he again moved away. About once in ten minutes the fluttering occurred on the part of the female; a little cloud of sand was stirred up, but I looked a long time in vain for an egg. At last one was thrown upward with the sand, and the male coolly swam toward it, opened his mouth, and it disappeared down his throat. His oft-recurring rigidities and tremors seemed to have no special connection with her throes, or the possible emission of eggs, which I suspected at these times, though without any evidence of sight. He was very brave in driving off the males that approached, but one large one came twice, while I was watching them, that he did not attack, but swam in between him and his mate several times, with an evident intention of keeping him from her. The stranger, however, in both instances placed himself near the female, and the same curving, and rigidity, and tremors were observed.

The last time the rightful groom swam away with the stranger, who gave him several punches with his jaws. The evident intention of the former seemed to be to entice the intruder away from the nest. He escorted him off for a long distance and returned again to his mate. After three hours' observation of similar maneuvers, I left them to pursue, undisturbed, their singular actions.

The whole conduct of the male toward the female was a continued series of caresses. He spent his whole time in circling around her, rubbing against her, and wheeling away to return again, and exhibited every evidence of jealousy when other males approached. No violence to the female was offered at any time by her mate, though I saw him twice bite her gently while the stranger-trout was near, as if communicating to her.

Seth Green, who has occupied hours in observing the movements of trout, thinks the whole movements I had the fortune to observe, were merely the usual actions of trout just subsequent to the time of spawning. They serve, however, to contrast the conduct of the male toward the female with that of the white-fish. Mr. Green says that occasionally when the female tries the patience of the male too long in refusing to enter the nest, he suspends moral suasion for a time and hurries her toward the nest with a vigorous use of nose and jaws. A vertical movement over the nest, and occasionally the pair locking their jaws together, as they rose, was what Mr. Green observed whenever the eggs were emitted by the female.

The brightness of the skin and colors, the white margin on the under fins, and the comparative thinness of body, distinguish the male at the spawning-season from the female, who is dark-colored, the outer rays

of the under fins tinged with blue, and the abdomen swollen at this period.

(22 *f.*) *Development of eggs and embryo.*—It has been proven by repeated observation by fish-culturists that the higher the temperature of the water in which the eggs are placed the more rapidly the embryo fish develops within the egg, and the sooner it escapes from its inclosure in the shell.

The temperature of the succeeding months after the spawning-period probably regulates to a considerable extent the time of hatching of the white-fish in the lakes.

On the 11th day of April, at Ecorse, on the Detroit River, I visited Grassy Island in company with Mr. George Clark. The inside of the bag of a seine was lined with millinet and dragged in the river, bringing ashore a great quantity of mud and the small forms of life inhabiting the bottom. Sifting and washing out the mud resulted in finding one little worm-like fish-embryo, one-half inch in length, which I at once suspected to be the specimen sought after. Other attempts with the seine failed entirely from taking any more.

Mr. Clark then proposed that we take a boat and search carefully on the surface for the young fish. Taking a pail and dipper, we shoved off our boat, and Mr. Clark pulling very slowly with the oars, I hung over the gunwale, and in a very few minutes found a little, active fish swiming with his head at the surface, and captured him with the dipper. He proved to be identical with the one taken with the seine. In the course of half an hour we captured forty, all of the same size and state of development. Most of them were taken within five or six inches of the surface, though they were frequently seen coming up from as far below as they were visible. They were nearly white, with a pair of large black eyes, were very active, moving continually, propelling themselves with a constant motion of the tail, and swimming with the head up and the body depending at an inclination of about fifty degrees. They seemed apprehensive of danger, and turned quickly from the dipper when it came near them, occasionally escaping. They had no gregarious instinct whatever, and though occasionally taken in pairs it was probably an accidental circumstance.

On April 14 we again visited the island and caught a number more of the young fish.

A few days later Mr. Clark and I visited the breeding-house of Mr. N. W. Clark, of Clarkston. He had put down a large quantity of white-fish ova in November, and had taken the water flowing over the eggs from a pond that had remained frozen over nearly all the winter. The temperature of the water had remained at 34° or 35°, and the young fish had begun to hatch out on the 1st of April, and about the 9th or 10th were all out of the shell. This temperature is probably much the same as Detroit River at Ecorse, sixty-eight miles below Lake Huron, the current flowing at the rate of two miles per hour.

The appearance of the umbilical sac in the specimens from both

places, made it evident that they were of about the same age, and indicated the fact that in waters that are frozen over throughout the winter the young white-fish escape from the egg about the first week of April.

The temperature of Lake Michigan, Huron, or Superior probably does not descend below about 40° or 43° in ordinary winters, and the young fish would be likely to make their appearance a week or two earlier.

The young fish lived in the glass jar of water two days, were then transferred to an eight-ounce bottle, and, carried over thirty hours by rail and steamer, and did not arrive at their destination, Waukegan, Ill., until thirty-six hours after they left Ecorse, Mich. They were all in good condition, and were placed in a quart jar of fresh water. There were thirteen of them altogether.

April 19.—The young white-fish are very vigorous, and are in continual motion. The water has been changed once. Although the yelk sac has not diminished, they act as if seeking food in their movements around the jar. They open their mouths very wide. Occasionally they take in dust masses, and eject them again as if they were unpalatable.

April 21.—Umbilical sac in one individual diminishing.

April 22.—Umbilical sacs reducing rapidly.

April 23.—Yelk-sacs being rapidly absorbed. The membrane on the anterior part of dorsal line is also slightly diminished.

April 24.—The umbilical sacs becoming minute. The fin-membrane anterior to position of dorsal becoming absorbed. At the center of the anterior ventral section of fin-membrane, a slightly opaque white spot is apparent. In front of the anus, and on lower half of caudal, are similar ones. The color of the head is assuming a greenish tinge.

April 25.—The globule in anterior part of yelk-sac has become divided up into numerous smaller globules, scattered like beads, or more like a row of bubbles, through the length of the sac. When they open their mouths the gill-arches show quite distinctly. Excrement voided by some of them.

April 28.—Umbilical sac entirely absorbed. First dorsal fin becoming well defined. Posterior section of dorsal membrane contracting. Furcation of caudal slightly indicated.

After an absence from home of six days, I returned on May 6 to find only one alive. A brown confervoid growth had developed in the water, and the young fish, attempting to swallow it, always got it entangled in its gills, and soon died.

In my absence I visited Clarkston and purchased for private parties from Mr. N. W. Clark one thousand young trout, which I brought safely to a brook two miles north of Waukegan, Ill. Mr. Clark gave me one hundred and fifty young white-fish, most of them with the yelk-sac only partially absorbed. The difference in temperature evidently made some

difference in the rapidity with which the umbilical sac disappeared, as the young fish I had carried home were in the same stage of development, April 14, as when I had visited Clarkston previously. Now, May 1, the fish in Mr. Clark's troughs still retained considerable of the sac, while on the 28th of April the young fish in the jar had lost it entirely. The jar had been kept in a moderately warm room, with a temperature of about 65°, while the water in the troughs at Clarkston flowed from a pond that had been covered with ice until within a few days previous.

(22 *g.*) *Food of embryonic white-fish.*—The young fish reached Waukegan in safety, and were placed in five quart glass jars, and an experiment begun in attempting to supply them with suitable food. A numbered label was pasted on each jar, so as to keep them distinct.

Knowing that the larger white-fish fed largely on crustaceans, an attempt to feed them on food of this character was thought worth a trial. A few craw-fish were procured and pounded to a paste, and small portions put into jar No. 1; the young fish ate it readily. They were fed at night, and the next morning every one of them was found to be dead. Jar No. 2 was supplied with bread-crumbs, and the fish were seen to take small particles in their mouths; they did not die so suddenly. Jar No. 3 was supplied with sweet cream, but no evidence was afforded that the occupants fed upon it. A quantity of rain-water was exposed to the rays of the sun for the purpose of generating minute forms of life, and a teaspoonful was poured into jar No. 4, morning and evening, in hopes that their proper food was of this character. In jar No. 5 a variety of food was provided, dry fresh beef, milk, boiled potato, and bread. The crumbs of bread and the scrapings from the beef were all that the fish were seen to take into their mouths. They died, one after another, very rapidly, and in a few days all were dead.

There were other things unfavorable to them, in these experiments, besides the lack of their natural nourishment. To conduct these experiments favorably, they should be placed in a large vessel, and a stream of fresh water should be supplied constantly so that the water should continue pure and the production of confervæ be avoided. This difficulty of procuring a suitable food for the young white-fish has been the experience of the few fish-culturists who have hatched them.

A set of specimens representing young fish from the Detroit River, from the troughs at Clarkston, and from the jars, were preserved in alcohol and submitted to Mr. S. A. Briggs, editor of the *Lens*, Chicago. A letter from Mr. Briggs contained the following:

"CHICAGO, *May* 28, 1872.

"MY DEAR SIR: The four vials containing *C. albus* came duly to hand, and have, with the alcohol and water in which the specimens were preserved, been carefully examined.

"The intestines of specimens No. 77 and 78, from Clarkston, were entirely destitute of organic matter recognizable under a power of 400 linear, which ought to be ample for the purpose.

"Those of specimens 76 and 79, from Detroit River, contained numerous specimens of two species of *Diatomaceæ*, viz, *Fragilaria capucina*, and *Stephanodiscus niagaræ*. The former is a filamentous form which grows very abundantly in our lake-inlets attached to stems of lilies. The latter is a large form which, from its peculiar build, contains considerable nutritious material.

"Very sincerely, yours,

"S. A. BRIGGS."

(22 *h.*) *Rate of growth of white-fish.*—Further research for the young fish was unavoidably delayed until the 1st of July. Towards the end of June, from a seine-haul at Waukegan, a specimen of *Coregonus albus* measuring eight and three-tenths inches in length, one of *C. quadrilateralis*, measuring seven and four-tenths, and one of *Coregonus harengus*, measuring three and four-tenths inches, were obtained.

At Sault Ste. Marie, Mich., on July 2, with an Indian in a birch canoe, the vicinity both above and below the rapids was explored in the current and in the still water and along the shores, to find the smallest grade of while-fishes that were to be had. Along the shore, in the sharp current, schools were found of which the smallest taken measured four inches and nine-tenths, and the largest six inches and one-tenth. It was quite evident that they had all been hatched the same season. Another excursion in the birch resulted in nothing materially different. The minimum measurement of the next grade taken was eight inches and three-tenths.

At Shoal Island, one of the Apostle Islands of Lake Superior, a white-fish was taken from the pound-net about the middle of August, measuring six inches in length, and another measuring six and one-half inches.

On the 3d of December, at Point Edward, Canada, at the outlet of Lake Huron, two specimens of *Coregonus albus* were obtained from a seine, one measuring six inches and eight-tenths, and the other seven inches and seven-tenths.

It is very probable that the Shoal Island fishes of August and the Point Edward ones of December 3 were the larger-grown individuals of the same generation as those taken at Sault Ste. Marie in July. The difficult point to decide was in what year the beginning of this generation should be placed.

The only positive data with reference to the growth of white-fish, are found in the observations of Mr. Samuel Wilmot, of Newcastle, Ontario, in charge of the government hatching-house of Canada.

Mr. Wilmot reports that in November, 1868, he placed a quantity of spawn in the hatching-troughs for an experiment, and in the following March and April a large number of young fry made their appearance. He failed in finding food adapted to the young fish, but a number that escaped through the screens were carried down to a small pond where they seemed to thrive and soon became well-developed young fish. In

the month of September they were exhibited at a fair in London, Canada. They were then about five inches long. In December the young fish had attained the length of seven inches.

Mr. N. W. Clark, of Clarkston, Mich., visited Wilmot's hatching-house in 1871, and in an address before the house of representatives of Michigan, said: "Enough is known from the success of Samuel Wilmot, Esq., of Canada, to sustain us in the assertion that they (the white-fish) increase in weight about three-quarters of a pound a year, as those he had when we saw them, last January, we judged to have weighed about one and a quarter pounds, being then about eighteen months old."

These are the only records of observations of the growth of the white-fish, and evidences of this character are the only ones of any value of the rate of growth.

An attempt was made several times from large lifts of fish lying in the fish-shanties to arrange the different sizes of white-fish in series, with the hope that some evidence of the rate of growth per year would result. It was always found that the row of fishes, from the larger to the smaller, assumed the form of a spire-like pyramid, and a "straight-edge" laid at their heads would have touched the noses of every one in the series, and on the opposite end it would have touched every tail, so perfectly regular was the gradation.

It was difficult to believe that the white-fishes, of from nearly five inches to six or seven, had attained these dimensions in three months from the little half-inch embryos of April and May, though none of less size were found with the most diligent search.

Mr. Wilmot's young fish measured about five inches in September when four months old. Experience has proved that there is a more rapid growth of the young trout and salmon afterwards than during the first two months. The observation on the development of the young white-fish from April to the first week of May showed the slightest perceptible difference of length and bulk. If we assume them to be the fish of this season, then they had increased ten times in length in two months, precluding the possibility of a more rapid growth afterward.

It is altogether probable that the fish measuring from four to seven inches in July were those of the previous season's hatching, and about sixteen months old. It is equally probable that the Point Edward fish of seven inches are those of the same season, as the five months intervening the 1st of July and the 3d of December should have produced considerable growth. To confirm this opinion we have Mr. Wilmot's statement that his white-fish had attained the length of seven inches in December.

These evidences of the rate of growth are the only conclusions we have been enabled to adopt with reference to the size attained at different ages. Nor does this decide the average size of the growth of the white-fishes the first and second seasons.

A very excellent opportunity of observing the sizes attained by the

brook-trout at different ages, was afforded at Mr. H. F. Dousman's hatching-house at Waterville, Wis.

There is a more uneven growth in the trout of the same season than among any of our familiar domestic animals, such as sheep, pigs, or chickens.

Mr. Dousman's fish of the season, hatched in January and February, measured at the time of my visit, October 25, from two and one-half to five inches in length; while his trout of the previous season, about one year and eight months old, were from seven to fourteen inches in length.

Mr. Dousman is a large feeder, supplying his fish with food regularly twice a day throughout the year. He has the most perfect arrangements for keeping his fish of different ages separate, as there is no possibility of their getting together other than being dipped out of one of the box-flumes in which they are separately confined and dropped through the trap-door of another.

The same great variation is found to occur in the parr and grilse stage of the salmon, and is probably the case with all the species of the *Salmonoidæ* at all ages, the lake white-fishes included.

(22 *i.*) *Average size of mature fishes.*—The average size of mature fishes, in different localities, varies greatly. The white-fish of the region of the Apostle Islands is a medium-sized fish. The entire catch of the numerous fisheries in their vicinity should not be estimated higher than one and a half pounds for all the fish marketed.

In Thunder Bay, on the northern shore of the lake, a lift seen in October contained fish that averaged about the same as at the Apostle Islands.

Mr. George Barnston, of Montreal, a naturalist, connected in former times with the Hudson Bay Company, says, with reference to the white-fishes of Michipicoten Bay and River: "The produce of our own seines and nets I always regarded as composed of one species of white-fish, and the same as that caught everywhere in the lakes."

A large type of white-fish is reported from localities in the western half of Lake Superior, taken at certain seasons. Mr. E. Alvord, of Sandusky, Ohio, took a white-fish at Madeline Island, one of the Apostle Islands, weighing twenty-two pounds and a half. Stories, not well authenticated, of specimens weighing twenty-four pounds and over, are common on Lake Superior.

In White-Fish Bay a type of white-fish is taken, said to average very large. A specimen was forwarded to Buffalo from this locality, this season, weighing twenty pounds.

In Bachewauna Bay, opposite White-Fish Point, Mr. Barnston speaks of the white-fish as longer, and much thicker and heavier, than those of Michipicoten.

At the foot of the Sault Ste. Marie Rapids the Indians fish in the swift current, from birch canoes, with large dip-nets, taking a type of white-

fish, in large numbers, that will average four pounds in weight. A specimen was obtained of one of them this season weighing twelve pounds.

The white-fish from the greater portion of Lake Michigan will average lower than those of Lake Superior. A locality on the north shore of the lake has a very large type of white fish, of which the average of lifts I have seen brought to the shore could not be less than four pounds. I was informed that eleven white-fish had been put into a package weighing one hundred and seven pounds and shipped to a man at Charlevoix, whom I afterwards saw and heard him repeat the fact. The gill-net mesh in use at this point was one-half inch larger than that of most points on the lake. Two specimens obtained at Point aux Barques weighed respectively ten and eleven pounds.

Lake Huron white-fish are moderately large. From the western end of Lake Erie a large type of fish are taken. Those ascending the Detroit River in the fall of the year average two and a quarter pounds. From the eastern portion of the lake the white-fish are smaller. The average of Lake Ontario fish is small.

(22 *j.*) *Ranges as to depth favored by young white-fish.*—It is quite evident that the young and immature white-fishes confine their range entirely to the shallow waters near the shore. The pound-nets set in from twenty to forty-five feet catch numbers of small fishes seven or eight inches in length weighing only a few ounces. The capture of a white-fish as small as seven or eight ounces is a very rare occurrence with the gill-nets, for which twelve or fifteen fathoms is the least depth ordinarily employed. Though making this a special point for observation during the tour of Lake Michigan, not a single specimen as small as eight ounces was seen among fishes taken from the gill-nets, and the percentage of fish as small as one pound in weight before dressing was inconsiderable.

A further confirmation of the in-shore range of young white-fish is in the fact that the catch of a pound-net set on a thirty-six-foot shoal, six miles from the land at Bay de Noquet, contained only Nos. 1 and 2 fish.

The head and mouth of the white-fish are so constructed that it is to a slight extent better guarded against entanglement in the mesh than its congeners, the lake herring and the cisco, so that there is a possibility that the small fishes pass through the meshes and escape capture. Still it is likely occasional ones would be taken, as all species taken by the gill-net are frequently found entangled about the body and fins, without any threads fastened in the mouth or even in the gills, and this often with the slender herrings and ciscos.

The fact already referred to, that no young-white-fish were found in the stomachs of the lake-trout, has an application here. The range of the trout in the warm season is in deep water, and as it is altogether likely the trout would make food of the smaller white-fishes if they were

to be found, the inference is natural that they do not range into the deep water.

From these observations it was evident that the white-fish were not found in any abundance in the deeper waters smaller than one and one-fourth pounds, and it is not until they attain about this weight that their migrations into the deeper waters of the lake begin.

From the examination of stomachs of immature fishes, the food was found to be small crustaceans and insects.

(22 *k.*) *Enemies of the white-fish.*—The largest percentage of destruction the white-fish suffers is without doubt in the ova-stage.

The spawn-eaters of the lakes are a numerous and widely distributed list of animals, including fishes, amphibians and, it is claimed, divers, and ducks. The destruction of the spawn by these methods is immense, and far exceeds the losses while in the stage of fry.

The most wholesale devourer of the eggs is undoubtedly the lake-herring. On opening the stomachs of the herring from the ponds in Detroit River, in November, they were found to contain the eggs of white-fish. At first it was considered possible that, as they were confined in the ponds, their eating spawn might be a matter of necessity, but later, at Sandusky, their stomachs were found gorged with the ova. The herring, the most numerous species inhabiting the spawning-grounds of the white-fish, are without doubt the principal agents in keeping in check the increasing numbers supplied from the fertilized ova.

The suckers, sturgeon, and smaller bottom feeding-fishes are found with spawn in the stomach.

The so-called "water-lizard," *Menobranchus lateralis* Say is very numerous in some of the streams and portions of the lake-shore. Mr. George Clark, of Ecorse, Mich., had a minnow-seine fitted to the bag of a sweep-seine, and at one haul took two thousand of the "water-lizards." Estimating the extent that the net had passed over, he calculated the average number of lizards to each square rod to be four. He says, further, in one of the Detroit papers, "The lizards were so gorged with white-fish spawn that when they were thrown on the shore, hundreds of eggs would fly out of their mouths. * * * Some of the larger lizards would devour the whole spawning of a white-fish in a day or two; and when we consider that these reptiles are feeding upon eggs from November till April, some idea may be formed of their vast capacity for destruction."

Mr. Browne, of Grand Haven, Mich., states that some three years ago an epidemic seemed to prevail among the *Menobranchi* in Grand River, in the month of June and that their dead carcasses were washed ashore by hundreds, so that they lined the banks of the river, and the mill-men were obliged to throw the bodies off into the current, to be carried down stream to prevent the offensive stench that was wafted into the mills from the decaying remains.

A fisherman at Evanston, Ill., a few years ago had nine hundred

hooks set in the lake, and in one day took from these five hundred lizards, removing them all himself, as his men, sharing the popular notion on the lakes, believed them to be poisonous, and preferred to cut away hook and all to taking hold of the slimy amphibian. They are, of course, entirely harmless in this particular, and make no more attempt to bite than a frog does.

A full series of this species was this season collected from Detroit River, from the length of one and one-fourth inches to thirteen inches. Later, about the middle of the month of July, Mr. George Clark collected a quantity of their eggs, proving this month to be the spawning-season of the animal.

The sturgeon are very generally believed to be spawn-eaters. Though the ova of the white-fish and the perch have been observed among the stomach-contents of this fish, the principal food has always been found to be snails, the fresh-water genera being generally represented, the weaker shells crushed into fragments, and the stronger ones of the *Paludinidæ* and even *Limneas* remaining unbroken.

Dr. E. Sterling, of Cleveland, who examined the stomachs of a large number of sturgeon in the vicinity of the Sandusky fisheries, made the same observation.

There are few of the bottom-feeding fishes but whose stomachs will not generally be found to contain a few eggs, though in company with other food in greater quantity.

The white-fish stomach is generally found to contain a few fish-eggs, though its principal food is the crustacea. The habit of leaving the shore immediately after spawning probably prevents it from being an agent in diminishing its own numbers.

The natural casualties of storms, deposits of sediment, smothering the eggs, the vegetable growth found to be so fatal in the hatching-troughs, are to be considered in this connection as the dangers, though more fully represented on another page.

In the fry-stage they must suffer to some extent from the piscivorous fishes. The most numerous and voracious of their enemies is likely to be the wall-eyed pike, *Stizostedion americana*, numerous in the shoal waters of the lakes and comparatively rare on the deeper shores. The perch, *Perca flavescens*, are very generally distributed and quite numerous; the contents of their stomachs are generally found to be vertebrate forms. The black-bass, *Micropterus nigricans*, is plentiful in Lake Erie, but as its ordinary food is the craw-fish, where these are numerous its depredations on the schools of young fish would be of comparatively little importance. The white-bass, *Roccus chrysops*, the muskellunge, *Esox nobilior*, and the lake-pike, *Esox lucius*, do not inhabit the lakes in sufficient numbers to be very troublesome to the white-fishes.

It is the prevailing idea on the lakes that the Mackinaw or salmon-trout feeds largely on the white-fish. This point has been fully considered on a previous page, and the evidences disproving it related.

As everywhere civilized man disturbs the balance of nature, and becomes the great enemy to all forms of life that do not conform to his artificial methods for their protection. Not only by the hundreds of artifices for the capture of the white-fish, but in the foul drainage from the cities, smelting-works, and manufactories, and in the quantities of sawdust from the mills, they are driven from their favorite haunts and spawning-grounds, and their food destroyed by waters tainted with fatal chemical combinations.

The white-fish, as far as my observations have extended, is infested with two external and two intestinal parasites. The external ones are a crustacean, a *Lernea*, and an annelid, the *Icthyobdella punctata*. The Lernean was found only in the Detroit River, adhering to the fish on the dorsal region, and with its bell-shaped sucker buried in the epidermal sheath of the scales. On the white-fish swimming in schools near the surface around the edge of the pond in Detroit River, it could be detected by close examination fastened to the fish. There were seldom more than four on one fish. The lake-herring, confined in the same pond, swam in close contact with the white-fish, but in no instance, although careful observations were made repeatedly of the herring while in the water and after capture, was the Lernean found upon them. In Lake Superior they are found to be numerous on the siscowet.

The Icthyobdellan, a leech of three-fourths of an inch long, grayish white in color, with brown tesselated markings, was seen in great numbers in the month of April, while the fishermen were lifting their nets from about fifty fathoms some fifteen miles out from Kenosha, Wis.

They covered the nets and fishes of all species, and fell in such numbers on the deck that it became slippery, and an old coat was thrown down for the man who was lifting the gang to stand upon.

They were very tenacious of life, living for a long time on the deck, and for several days in the bilge-water of the fish-boats.

They were in such numbers that it was difficult to decide whether they had a preference for any species, and were found filled with blood both in the gills and while attached to the body, though it was difficult to imagine that they could fill themselves with blood from the epidermal sheath of the scales. They were thought to be most numerous on the white-fishes, as they were in greater numbers on them than on the trout, the lawyer, or the cisco, the only other fishes taken.

A prevailing but mistaken opinion in the vicinity was that the white-fish fed upon the leech. Dr. Hoy's investigations disproved the notion, and all examinations of stomach-contents confirmed this fact. One of the intestinal parasites resembled the leech somewhat in form. The other was an *Echinorhynchus*. They were never found within the stomach, but always in the duodenal portion of the intestine near the mouths of the cæcal tubes.

23.—THE LAKE-HERRING.

The so-called lake-herrings, *Argyrosomus clupeiformis*, (Mitch.,) and *A. harengus* (Rich.,) are very numerous in the shoaler waters of the lakes.

In the shoal regions of Green Bay and Lake Erie they are found in vast schools, crowding into the pound-nets in masses until the "cribs" are filled to the surface of the water. In Lake Erie frequently a corner of the net is lowered and a large proportion of them allowed to escape before the remainder are thrown into the boat. Although they have been taken in this way for years, there is no apparent diminution in their numbers. Perhaps the little disposition on the part of the fishermen to catch them in some measure accounts for this fact, though there must be, as well, some natural advantages in their prolificity and in the tenacity of life of the egg. They are little sought after because they are not a favorite fish in the market, being rather deficient in qualities as a fresh or salt fish, though having no objectionable flavor. They are small and thin when opened, and become shrunken when pickled. A mode of curing them, lately adopted at Waukegan, Ill., and Sandusky, Ohio, makes them the most delicious food. It is merely a slight pickling in salt brine, and then exposing them to the smoke of a hot fire for a short time. By this process they are prepared for eating without any further cooking, and are very much superior to the ordinary smoked herrings. They will keep two or three weeks in hot weather when but slightly smoked The profit on them to the fishermen is less than any other fish handled from the lakes, because of the low price they command in the market, and the expense of dressing and packing is much greater than in white-fish, trout, or pike, because of their smaller size.

The greatest length attained in an overgrown specimen seen at Point Edward, on the Canadian side of the head of Saint Clair River, was about nineteen inches in length, and it weighed about two pounds. The average length is scarcely one foot and the weight about nine or ten ounces.

Differing from the white-fish in the construction of the mouth, it being terminal, they more readily take a bait, and may be fished for with hook and line with a suitable bait. Insects are the best for this purpose, though they are frequently taken with a minnow. The contents of the stomach have been obtained in but a few instances, the fish being taken almost exclusively in the pound-nets, and in these they have generally remained long enough to digest the stomach-contents. A few specimens from seines in the Detroit River were found to contain insects and a few of the *Gammaridæ*, but no remains of vertebrates, though the herring are frequently taken with a minnow bait. They were found, by examination of the stomachs during the spawning-season of the white-fish, to be spawn-eaters of the worst character, their stomachs being crammed with white-fish ova, and, considering the great numbers of the herring, and their vicinity to the spawning-grounds, the destruction they effect must be very great.

Although a very general opinion prevails, in different parts of the lakes, that the herring spawns earlier than the white-fish, the opportunities afforded for observation, this season, indicated otherwise.

In Green Bay it was asserted that the herring came on to the shore in masses about the 6th of November, and although they were found in more or less abundance at all seasons of the year, there was a very evident general movement at that time. The only positive evidence of the fact of spawning is the emission of spawn by the fish when handled, and the migrations of the schools and the mere fact that the spawn are large does not determine the season of spawning. In regions where fishing is not carried on late in the season, it is a very common habit among the fishermen to conclude on some particular time during the fishing as the spawning-period, basing the belief on migration or appearance of the spawn, when, in reality. the fish do not spawn until after the fishing-season closes.

By November 25 of last year, the majority of white-fish in the western end of Lake Erie were found to have finished spawning. With few exceptions the ovaries were emptied of their load of eggs; the abdomen was wrinkled and flaccid, and but few eggs were emitted when thrown into the boats or on the fish-house floor. The lake-herrings at this time were found to be full of ripe eggs, which were voided from the ovipore of females whenever the fish was moved, and even while lying in heaps on the bottom of the boats or floors of the fish-houses. Earlier than this, between the 1st of November and the 20th, examination of the ovaries on nearly every day had found, in the larger proportion, the ovaries hard and compact.

The herring were taken at this time in their usual haunts, the pound-nets capturing them in immense quantities, making it probable that they do not change their locality in the spawning-season. What their subsequent habits may be, would require observation later in the season than fishing is generally carried on, though the new custom of allowing pound-nets to remain until the ice has covered the bays would afford a favorable opportunity. If they remain upon the spawning-grounds they would undoubtedly be their own worst agent of destruction.

In the winter of 1871, in Green Bay, to the south of Escanaba, Mich., it was discovered that the herring had congregated in large numbers in an open space free from ice next to the shore where a number of springs in the bank supplied a quantity of water of too high a temperature to freeze readily. Minnows were found crowded in masses at the water's edge, and using them for bait the herring were taken in large numbers, and occasionally a white-fish from about twenty inches of water.

All that is known of the time of hatching of the herring-ova is from the experiments of Mr. Seth Green.

In the report of the commissioners of fisheries for the State of New York for the year 1871, it is stated that a quantity of the impregnated

spawn of the lake-herring was obtained and treated similarly to the white-fish ova. It is stated that "their time of incubation is about the same [as the white-fish.] The newly-hatched fish are very small, not exceeding three-eighths of an inch in size. The umbilical sac lasts but a few days, and the fish begin to swim and feed as soon as they come out of the shell. They are as active at one day old as the trout at two months. The young fish, being so small and delicate, are, of course, hard to keep. * * * They have increased in size faster than the white-fish, and the indications are that they are a more hardy fish and more easily raised."

The ovaries of a specimen examined weighed two ounces, and contained sixteen thousand and forty eggs.

At Waukegan, Ill., from a seine-haul on the 23d of June, a number of young herring were swept in with the larger fish, measuring from three and one-third inches to four and a half inches. At the rapids of the Sault Ste. Marie River a number were taken, from among the rocks near the shore, on the 2d and 3d of July, that measured from two and five-eighths inches to six inches in length. It is probable that the smaller grade were the fishes hatched the previous year.

On the 3d of December last herring were taken with a minnow-seine, at Point Edward, measuring from five inches to the size of mature fishes, the smaller ones being in all probability the same generation as those found at the Sault Ste. Marie earlier in the season.

Besides its enemies among the spawn-eaters, the herring has much the same class of enemies as those already enumerated for the white-fishes.

Of the parasites the most marked species is a *Bothriocephalus* found in the muscles of the dorsal region. They measure two or three inches in length and are found in masses between the intermuscular fasciæ of the back. The specimen in which the parasites were found was taken in Detroit River in the month of April, and though not observed after the month of June, it is certainly common earlier in the season, as the fishermen are familiar with the fact. A parasitic worm has also been seen in the intestine.

The external parasite of the white-fish, a *Lernæa*, was not seen attached to a single specimen of the lake-herring where hundreds were continually passing in the confined ponds of Detroit River, though they were seen to be very common on the white-fish. Nor were any specimens of the *Echinorhynchus* found in the intestines, though a white-fish is seldom examined without finding them numerous.

24.—THE LAKE-STURGEON, *Acipenser rubicundus*.

(24 *a.*) *Synonymy.—Acipenser rubicundus*, LESUEUR, Trans. Amer. Phil. Soc., (new series,) i, p. 388, pl. 12; RICHARDSON, Faun. Boreal. Amer., iii, p. 28‡; FITZINGER and HECKEL, Ann. Wien. Mus., i, p. 316; DEKAY,

Zool. N. Y. Fishes, iv, p. 344, pl. 58, fig. 191; STORER, Synopsis Fishes N. A., p. 248; THOMPSON, Hist. Vt., part 1, p. 149.

Acipenser ruthenus major.—FORSTER, Phil. Trans., lxiii, p. 149, [Young.]

Acipenser rupertianus.—RICHARDSON, Faun. Boreal. Amer. Add., p. 311, pl. 97, [Young;] STORER, Syn. Fishes N. Am., p. 249, [Young.]

Acipenser laevis.—AGASSIZ, Lake Superior, p. 267; DUMÉRIL, Hist. Nat. Poiss., ii, p. 151, pl. 17.

Acipenser carbonarius.—AGASSIZ, Lake Superior, p. 271, pl. 5, [Young;] DUMÉRIL, Hist. Nat. Poiss., ii, p. 111, [Young.]

Acipenser rhynchæus.—AGASSIZ, Lake Superior, p. 276, [Young;] DUMÉRIL, Hist. Nat. Poiss., ii, p. 179.

Acipenser oxyrhynchus.—THOMPSON, Hist. Vt., part i, p. 149.

Acipenser maculosus.—GÜNTHER, [in part,] Cat. Fishes Brit. Mus. viii, p. 339, [Young;] DUMÉRIL, Hist. Nat. Poiss., ii, p. 114, [Young.]

Acipenser anthracinus.—DUMÉRIL, op. cit., p. 126, pl. 15, [Young.]

Acipenser megalaspis.—DUMÉRIL, op. cit., p. 135, [Young.]

Acipenser lamari.—DUMÉRIL, op. cit., p. 139, [Young.]

Acipenser kirtlandii.—DUMÉRIL, op. cit., p. 161.

Acipenser nertianus.—DUMÉRIL, op. cit., p. 162.

Acipenser buffalo.—DUMÉRIL, op. cit., p. 231, [Young.]

(24 *b.*) *Characters separating it from other American species.*—In comparisons with the limited number of specimens of other species that are available, the more prominent differences between this species and the others were found to be in the following characters:

In general form there is perhaps one American species, *A. oxyrhynchus*, more elongate. The mouth is large, compared with the species mentioned and with *A. brevirostris*. In the size of the area of naked skin around the eyes and nostrils, it agrees with *A. acutirostris*, and differs from the other American sturgeons, in which it is very perceptibly larger, apparently reaching its maximum in *A. transmontanus*.

A. oxyrhynchus, in the specimens at hand, is well distinguished from the lake sturgeons, as well as other American species, in the proximity of the frontal plates, usually merely separated by a naked strip of skin, the last-mentioned character very marked in the young specimens. In *A. rubicundus* and others, the ethmoid plate extends high up between the frontals, separating them entirely. Exceptions to this fact are very rare, the only one that has come under our observation being in a young specimen of *A. maculosus*, from the Ohio River.

There are no plates surrounding the anus, as in *A. oxyrhynchus* and *A. brevirostris*. In the fact of the presence of well developed shields posterior to dorsal fin, it is different from *A. transmontanus* and *A. medirostris*. The variations in the number of shields in the dorsal series, in a very large number of observations at the lake-fisheries, was found to be between 11 and 15, the number of 13 being found most frequently. In this, though a variable character, it is pretty definitely separated from the other species, except *A. transmontanus* and *A. brachyrhynchus*.

The variation in the lateral series was within the numbers thirty and thirty-nine, the most often-recurring number being thirty-four. In this character it is well separated from *A. oxyrhynchus*, *A. brevirostris*, *A. transmontanus*, *A. acutirostris*. The number in the ventral series was found to vary between eight and ten. From *A. maculosus*, of the Ohio River, a very constant character differing from *A. rubicundus* was observed in the longer blades of the keels on the shields, they being prolonged backward and the points or hooks directed posteriorly, while in the lake species the keels are more central and their points rise nearly vertically.

In the obsolescence of the plates, certain species of the old world are similar. Kirtland claims the same fact for the Ohio River sturgeon. In a specimen of *A. transmontanus*, in the National Museum, the same tendency is indicated, the plates of the body having become thin and wafer-like and no appearance of the keels remaining, though in younger specimens the keels are prominent and sharply hooked.

The skin throughout is covered with tooth-like points, and is unlike other American species in the minuteness of these interserial ossifications, except *A. transmontanus* and *A. medirostris*.

The snout in the adults is very much obtuse and rounded, and its cartilaginous extremity very little protected by plates. Its great reduction in length, with age, makes it an unreliable element in calculating the proportions of the body, and in the table of proportions it is, for this reason, not included in the measurements of the specimen; the proportions of parts to the length of the trunk being calculated with reference to the distance from the opercular opening to the end of the lateral series of plates, and the parts of the head to its length, are calculated with reference to a measurement from the orbit to the posterior edge of the opercular opening.

(24 *c.*) *Different characters in old and young sturgeons.*—The great number of species of sturgeons made by numerous authors has resulted not alone from basing them on characters of insufficient value, but from the great differences in the appearance of old and young specimens. These differences are in the snout, which is, in young specimens, long and slender, but whch, by being absorbed or failing to grow as rapidly as the rest of the body, in the large sturgeons has a blunt and obtuse form; and in certain species, in the possession of large, well-developed shields in the younger ones, and their gradual disappearance as they mature and attain full size.

Allusion has been made by Dr. Kirtland to the fact of the disappearance of the shields in certain American species as the fish increased in size. In accordance with this view, he placed the names of several species of other naturalists as synonyms of *A. rubicundus*. This arrangement was accepted by Storer and introduced in his Synopsis of the Fishes of North America.

Günther refers to the tendency to variation in these characters in the common European sturgeon.

Duméril refers to the shortening of the snout and wearing away of the plates, but is not influenced by his knowledge of the fact in establishing species.

Among many hundreds of sturgeon of different sizes brought in from the nets and landed while we were visiting the fisheries of Lakes Michigan, Superior, Huron, and Erie, not a single specimen was seen, of a size of three feet or less, in which the five rows of shields were not developed and keeled; and if the young of the larger individuals are not represented in these, they are not taken by the seines, pound-nets, or gill-nets that gather in fishes from all parts of the lakes and streams.

Up to an average length of about twenty-five inches the shields increase somewhat in size; afterwards there is a gradual diminution by the wear of the keels and the absorption of the shield at the edges and base. The snout, too, from the thin, elongated point of the smaller individuals, is dwarfed into the short, obtuse anterior extremity of the larger ones.

Besides the examination of a large number at the fisheries with the object of determining the number of species, we have made a minute examination of twelve specimens, of from one foot three inches to five feet seven inches in length, from the lakes, with the following results: In specimens of fifteen inches and less in length the shields are distinct, large in proportion to the size of the fish, but crowded and imbricated; up to about twenty-five inches in length the shields increase somewhat in size and become less crowded. The shields of these smaller specimens have well-developed keels, terminating in a hook or spur, with a sharp point. In those a little larger the points are found dull and the hook disappearing. The keel, finally, is no longer apparent, leaving the white, worn mark of its base on the shields. The shields decrease in size from the edges; those just anterior to the ventrals are the first found missing; the ventral shields disappear entirely, and the posterior dorsal shields are next found missing, until a few of the anterior ones are barely distinguishable; even the callosities of the skin, showing the former position of the shields, become effaced, so that it is impossible to count the number of ventral or dorsal shields. The lateral series are the most persistent, and have never been found in our observation entirely effaced. In a description of a specimen from Lake Erie, Duméril gives the absence of the lateral shields as one of the characters. [Hist. Nat. Poiss., p. 151.]

This entire disappearance of the ventral shields is almost without exception in the full-grown specimens. Examination of hundreds of specimens at the fisheries of the Detroit River, at Sandusky, Ohio, where a very large quantity are taken, at Waukegan, Ill., Calumet, Ill., and the Lake Huron and Lake Superior fisheries, proved this fact beyond question, the only exceptions being the retention of a remnant of the

shields, like a small button, in a few mature specimens. The keels of the dorsal shields have been seen in a few individuals slightly prominent, where they had attained the length of about three feet, though these might not have been older than some of a smaller size who had not had so rapid a growth.

(24*d.*) *Description of adult specimen.*—Head from orbit to pectoral arch, .20 of length of trunk; an oblique line from orbit to posterior of supra-occipital plate, .19 of length of trunk.

The following proportions are given in one-hundredths of the distance from the orbit to the posterior edge of opercular opening, measured in a line with the axis of the body: Width of head at anterior nasal orifices, .34; width of head at orbits, .50; width of head at temporal plates, .61½; width of head at narrowest part of opercular openings, .54¼.

P. 40; D. 35; A. 26; C. $\frac{33}{87}$.

Dorsal shields, 4 anterior ones apparent; lateral shields, 38, reduced to indistinct, narrow remnants; ventral shields, no trace remaining; shields separated and without keels.

Length, 5 feet 7 inches.

Locality, Ecorse, Mich., Detroit River.

(24*e.*) *Description of young specimen.*—A comparison of young specimens with mature ones shows the greatest differences to be the development of the shields, and the very much longer snout. The number of fin-rays, the series of shields, and the form and arrangement of the bones of the head, on all but the rostrum, correspond to the older specimens.

Head from orbit to pectoral arch, .17 of length of trunk; an oblique line from orbit to posterior of supra-occipital plate .16½ of length of trunk.

The proportions of the head are given in one-hundreths of the distance of the orbit to the pectoral arch. Width of head at anterior nasal orifices, .40; width of head at orbits, .59; width of head at temporals, .70; width of head at narrowest point of opercular openings, .66¾.

P. 37; D. 37; A. 24; C. $\frac{30}{94}$.

Dorsal shields, 11; lateral shields, 34; ventral shields, 8 and 9; keels slightly worn.

Length, 28.2 inches.

Locality, Bayfield, Wis., Lake Superior.

Specimens from Lakes Erie, Huron, Michigan, and Superior have no more variation in characters than can be found among the specimens taken at a single fishing ground.

(24*f.*) *Size of mature fish.*—The sturgeon of this species attains the largest size of any fish of the lakes. They are taken only within comparatively shoal waters, and in some of the bays, and among the islands they are very abundant.

The largest specimen it has been my fortune to see did not quite attain the length of six feet, though there are traditions in localities on

the lakes of nine-foot sturgeons. The average of the mature ones taken is less than five feet.

(24*g*.) *Numbers.*—In numbers they will not compare favorably with any of the staple food-fishes. At Sandusky, Ohio, where they are more numerous than in any other locality, except, perhaps, Green Bay, Wis., there were about fourteen thousand mature sturgeons handled, weighing about seven hundred thousand pounds, obtained from about eighty-five pound-nets.

(24*h*.) *Economical value.*—As an article of food they are not generally popular. But few people in the cities know the modes of cooking that make their meat a palatable dish. A certain quantity is disposed of fresh by the peddlers. With the Canadian-French people of the lake-shores they are in demand, and are prepared in the form of soups, (*bouillon.*) With a good, hearty out-door appetite, this is very palatable food, but too rich in the flavor of the oil of the fish for ordinary use. The flavor of sturgeon-meat has very little of the taste of fish, and the *bouillon*, when carefully prepared by skimming off the oil, is very much like chicken-soup. A very good pickled meat is made of it by boiling it and preserving it in vinegar.

But the best form of preparing sturgeon is by smoking it. The smoking of sturgeon-meat has been done at different points of the lakes on a small scale, but is only carried on to a large extent by Schacht Brothers, of Sandusky, Ohio. The method employed by this firm is the following: The sturgeons are skinned and the viscera taken away. The thick parts are then cut into strips, and after a slight pickling in brine are smoked over a close fire. The thin portions and offal are boiled down for oil; the spawn is made into caviare; and from the bladders isinglass is manufactured.

The smoked sturgeon is a most palatable meat, and is quite popular, making an excellent substitute for smoked halibut, and, in the opinion of a great many, having some qualities superior.

The caviare is made by pressing the ova through sieves, leaving the membranes of the ovaries remaining in the sieve, and the eggs falling through into a tub. This is continued until the eggs are entirely free from particles of membrane, when they are put into a salt-pickle and allowed to remain for some time. Nearly all the caviare is shipped to Europe while in the salted condition. [For full account of manufacture, see appendix; Account of Fisheries and Phoca hunting, &c.]

Mr. Schacht says they use from ten to eighteen thousand sturgeon a year, receiving during 1872 thirteen thousand eight hundred and eighty, averaging fifty pounds each. Before this firm began their work, the sturgeon taken by the nets were uselessly destroyed or sold by the wagon-load for a trifle, just as is the case in Green Bay, Wis., at the present time. The firm at Sandusky settled at that point only a few years ago, bringing with them but a small amount of money. They now own their curing-house, warehouse, and freezing-house, all neat, well-

arranged buildings for their purpose. A good substantial dock adjoins the buildings. They have interests in other profitable investments at Sandusky, and are generally well to do. The sturgeon has been the main part of their business, though they have smoked other fish for the market, principally the lake-herring. Out of a shameful waste of a large supply of food they have established a large and profitable industry.

The details of their success are reported because in the other parts of the lakes, excepting the vicinity of large cities, where they are generally marketable, the sturgeon are destroyed in the most wanton and useless manner, and there is the opportunity in Green Bay, Wis., for some one with skill and enterprise to succeed to an equal extent, and to utilize thousands of pounds of food that are wasted every year.

Visiting a firm in Chicago, who handled smoked sturgeon, I learned that their books contained orders for much more than they could supply, and they were willing to pay a round price for the article. The fishermen would, of course, be willing to sell the fresh sturgeon as they are taken out of the net, but think they cannot afford the trouble of smoking the quantity they capture in their own nets. The Sandusky firm are not net-owners, but purchase all their fish, and the same arrangement is necessary in this locality. Some of the Lake Michigan fishermen owning a small steam fishing-boat would be the best prepared for this work as they could gather up the catch of each day from a large number of nets and carry it to the curing-establishment. The sturgeon could be obtained for a mere nominal price, as the only care among the fishermen of the locality, during my visit in 1871, was to get rid of them to the best advantage. [This enterprise has been lately begun by a man well qualified to succeed.]

(24 *i.*) *Range of Sturgeon.*—The chosen range of the sturgeon is the shoaler waters of the lakes and their bays. They are very abundant among the islands at the western end of Lake Erie, in Green Bay of Lake Michigan, and at the southern end of this lake. Chaquamegon Bay of Lake Superior, near the Apostle Islands, has them in numbers. They are found in all localities in more or less abundance.

(24 *j.*) *Food.*—Their food consists almost entirely of the shell-fish of the lakes, principally Gasteropods—the thinner-shelled kinds of the genera *Physa*, *Planorbis*, and *Valvata*, being found broken in the stomachs, while *Limnæa* and *Melantho* remain whole. A few eggs of fishes have been found at different times, but examination of stomachs during the spawning-season of some of the most numerous fishes did not prove them to be very extensive spawn-eaters.

(24 *k.*) *Habits in the spawning-season.*—The spawning-season of the sturgeon in the more southern lakes occurs in the month of June; in Lake Superior it is a little later. Early in June, in the southern end of Lake Michigan, they begin to congregate near the shores and at the mouths of the rivers, the Kalamazoo River, emptying at Saugatuck, Mich., being a favorite spawning-ground. They may be seen in the

evening in this river, leaping from the surface, throwing their bulky forms entirely out of the water. At Pier Cove, Mich., on the 11th of June, 1871, schools of sturgeons were at the edge of the shore in a few feet of water, and men from the vicinity were in the habit of wading out and drawing them ashore with gaff-hooks. Eighteen were taken in this way the morning we visited the locality. They were said to be found in the vicinity every year about this season, remaining about a fortnight. It is likely they were spawning at the time. Whether the shore of the lakes, where the waves would disturb the eggs in every storm, is a natural spawning-ground, is a question. They may have been late arrivals seeking the mouth of the Kalamazoo River, a few miles to the north of which they are said to ascend to the first dam, many miles inland.

Mr. J. G. Portman, of Benton Harbor, successful as a fish-culturist, has seen the sturgeon at this season lying in numbers on a shallow clay ledge at the edge of a stream, several of them lying flat on their backs, with their bellies upward, rolling and splashing in shallow water, with apparent enjoyment. Two or three that were taken with spears were opened, and the stomachs examined, and found to contain some of the sturgeon-spawn. At the mouth of Calumet River, South Chicago, Ill., July 1, of the year just referred to, a large lift of sturgeon were brought ashore, looking flaccid and emaciated, and but one specimen out of over twenty individuals contained spawn. In the vicinity of Bayfield, Wis., Lake Superior, they were seen late in the month of July with the ovaries full of spawn, and the milt of the male fishes large, making it probable that the time of spawning was later in colder waters than in warm.

(24 *l.*) *Enemies.*—In Green Bay the fishermen set their pounds for fall-fishing about the 10th of September. The sturgeon are in abundance and the nets often contain a hundred or more. This is said to continue until about the middle of October, when they diminish in numbers and the white-fish become plentiful. As the latter are the fish sought for, the sturgeon are considered a nuisance and annoyance. A few fishermen are considerate enough to lower the corner of a net and allow them to escape, but the commoner way is to draw them out of the net with a gaff-hook and let them go wounded, or to take them ashore and throw them on the refuse-heap, asserting that there will be so many less to trouble them in future. A very large number are destroyed in this way, probably equaling or excelling the number taken in the vicinity of Sandusky.

The spawn is probably subjected to the depredations of numerous fishes. It is not likely that the young sturgeon, except in the earliest stages of their growth, suffer from the attacks of other fishes, as they are too well defended with the sharp spine of their shields to make a comfortable mouthful for any fish of the lakes, and after the spine disappears have attained a size large enough to render them safe.

A parasite that troubles the sturgeon is the lamprey-eel, *Petromyzon*

argenteus Kirt., which is found very frequently attached to the skin. The circular scars and raw sores sometimes found upon the sturgeon, and attributed to this cause by the fishermen, are correctly accounted for in this way. It is probable that their natural food is the slime or mucus exuded in abundance from the pores, but they fequently retain their hold upon a spot until they have eaten through to the flesh, and deep ulcerous cavities occasionally result from the sore.

The decrease in numbers is apparent, to a certain extent, in localities where the pound-net has been in use for a number of years. At Sandusky, Ohio, the numbers brought in from the nets and handled at the curing-establishment in a season are said to have nearly reached eighteen thousand a few years ago, while in 1872 the books showed a record of thirteen thousand eight hundred and eighty received. This fact has several times been advanced as an argument in favor of the pound-net, that the destruction of the sturgeon, asserted to be an extensive spawn-eater, more than compensated for the numbers of white-fish taken.

25.—An important species.

There is another species of fish, the wall-eyed pike, *Stizostedion americana*, a knowledge of whose habits would be important to a proper conservation of the species, but its spawning season is in the spring and earlier than circumstances have permitted us to visit its localities.

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II.—MISCELLANEOUS NOTES AND CORRESPONDENCE RELATIVE TO THE WHITE-FISH.

A—THE WHITE-FISH OF THE GREAT LAKES.

1.—LAKE SUPERIOR.

MONTREAL, *November* 2, 1872.

DEAR SIR: Touching the white-fish sent by me to the Smithsonian from Michipicoten, so long a time has elapsed since then that I cannot recall the particular circumstances. This I remember, however, that in Michipicoten Bay itself there is no great disparity in the size of the *Coregoni*. The produce of our own seines and nets I always regarded as composed of but one species of white-fish, and the same as that caught everywhere in the lakes and rivers of the North; but in spring we sometimes had sent to us from a small outpost at Bachewaino Bay a fish or two, longer than our own and much thicker and heavier. Without having entered into any careful examination, I used frequently to declare my opinion that they might be, possibly, a distinct species. It is very possible that a skin of one of these Bachewaino fish might have been forwarded by me to the Smithsonian, with other subjects of natural history. They are found in Bachewaino Bay, and I am told also, by a gentleman who was long a resident on the north shore, that Pancake Point, farther eastward, is a famous locality for their catch. I never had an opportunity of submitting these white-fish to a close comparison with the large specimens taken at the Sault Ste. Marie, below the rapids, but I conjecture they might be of the same species. In this particular, however, I might have easily fallen into mistake. For the table, these are a drier fish than the smaller common white-fish, and they occur in far less numbers in the places to which they resort. Occasionally a very large white-fish is taken about Fort William, no others approaching it in size, and they are looked upon as overfed monstrosities by the people at the posts. At Norway House, north end of Lake Winnepeg, where I resided many years, I was in the custom of sending a fisherman, late in the fishing season, in October, to the narrows of a river twenty miles distant, to obtain a larger and finer fish than what were to be had at the place. The reason for sending was, of course, the fish being larger, and equal in quality for food to those caught nearer. Still, upon inquiry I could never get the natives to say that it was of a different kind. They seemed to think the difference in size arose from the greater abundance or better quality of their food.

I believe Major Long was correct in saying that the white-fish run up the Michipicoten River to spawn, but they cannot and do not run up far, for very high falls and long sweeps of raging rapids obstruct their course in both the main river and its tributary, not far from the Great Lake. Half a mile above the station I have assisted in seining white-fish at the spawning season, and succeeded occasionally in making a good haul. These fish must have come from the bay or lake, for they could never have descended the falls in safety, and the native fishermen (in all such cases good judges) considered them lake-fish.

Can you inform me whether you have ever received from the north shore of Lake Superior any specimens of the "Mucqua trout" of the natives? as translated by me, the "bear trout," or *Salmo ursinus*. It is still fatter than the siskowet, and can be melted, with little residue, into oil. I have named it a distinct species, following the idea of the Indians, and observing it to possess a different shape of body and head entirely from the siskowet. It is found in small numbers throughout the lake, along the north shore, but, like the siskowet, prevails most in the neighborhood of the Pic. Can it be hybrid between *namaycush* and the siskowet?

GEORGE BARNSTON.

2.—LAKES ERIE AND ONTARIO.

DOMINION OF CANADA,
Hamilton, Ontario, November 18, 1872.

SIR: I had the honor to receive from the minister of marine and fisheries of this Dominion, recently, a circular directing me to procure specimens of white-fish from those localities of my district situated in Lake Ontario and Lake Erie, and to forward the same to you; and to accompany them by any remarks on their habits and varieties I may think of interest.

In obedience to the instructions received, I now send you four large white-fish I obtained in Lake Erie, near Port Dover, in the township of Woodhouse, county of Norfolk, and province of Ontario, in this Dominion. You will find the fish male and female.

I also have the honor to send you at the same time four smaller white-fish I procured in Lake Ontario, at Wynona, in the township of Saltfleet, in the South Riding of Wentworth, province of Ontario, and Dominion of Canada. I believe you will also find the latter four fish male and female.

The white-fish at this season of the year, fall and winter, feed on small shell-fish. This you can ascertain yourself by analyzing the contents of their stomach. In spring and summer they feed on a kind of shrimp-like insect; and from my knowledge and experience I have never known them to change to any other kind of food than those two kinds now described to you by me.

The white-fish spawn, both in Lakes Erie and Ontario, on the reefs and rocks, during the month of November. The eggs dropping into the crevices of the rocks are protected from suckers, a fish always on the alert at this season of the year to devour the eggs.

The two specimens sent herewith, you will please find by examination differ from each other in many respects. This you will be able to find out to be the case only by close study and observation. The Lake Ontario fish you will find to be a finer and superior fish than the Lake Erie white-fish, both in delicious delicacy of flavor and taste, and the whiteness and richness of the flesh. Still as regards the food for this fish, in both lakes, I have in every instance and on all occasions found it the same. The fish live by suction.

There is an observable difference in the shape of the white-fish of Lake Ontario as compared with the shape of the white-fish of Lake Erie.

Thus you will please find that the Lake Ontario white-fish are rounder and broader on the back, while the Lake Erie white-fish are flatter and sharper on the back. You can also find out other little differences by actual measurements of the fish, and this at the different parts of them; and which I have been able, by strict accuracy and study, to set at rest.

I have packed the eight white-fish I now send you in cut straw in a small box, which I understand will preserve them sufficiently for your purpose until they reach you at Washington; and I shall feel greatly honored if your learned views and researches will hereafter in any manner correspond with my humble assertions regarding this delicious fish.

I have the honor to be, sir, your obedient servant,

JOHN W. KERR,

Fishery Overseer, Hamilton District.

Professor SPENCER F. BAIRD,

United States Fishery Commissioner, Washington, D. C.

WOLFE ISLAND, *December* 4, 1872.

SIR: In obedience to instructions from the minister of marine and fisheries, I have the honor to send you, by this day's express, some specimens of our white-fish, taken in Lake Ontario, and I have been further instructed to accompany them by such remarks on their habits and varieties as I might think of interest. I would therefore beg to state, from having long experience as a fisherman, that the white-fish which are found in the Canadian lakes are social in their habits, moving about in shoals or great numbers. Three species may be enumerated, quite distinct from each other. The first has a very small head and a rounded back, and is known as the "Bow-back." This is considered the best species for food. The second has also a very small head, and a dark, round body, something resembling that of a sucker. The members of

this species are the smallest, upon an average, among the white-fish tribe, and they are, moreover, inferior to those of the other two species. The third species, and the one most common in the lakes of this part of Canada, has a common-sized head, and a regular and symmetrical body. The fish of this species average in weight about three pounds, although some are caught which go as high as ten pounds. In the lakes of the back country they are said to be generally larger, averaging as high as five pounds. In Lake Ontario white-fish are caught in the early spring, at some considerable distance from shore, and in about 200 feet of water; but about the 1st of June, as the summer approaches, and the weather gets warmer, they approach the shore and are then caught in great numbers, upon their favorite feeding grounds, which consist of a sort of a honey-combed rock, in about 30 feet of water. Their food consists chiefly of small worms, obtained from the porous rock of the bottom, and different kinds of aquatic insects. About the 1st of August, as the water begins to be uncomfortably warm for them, they retreat precipitately toward the deeper and cooler portions of the lake, and it is at this time that we find them in their best condition. About the middle of October they return toward the shore for the purpose of spawning, arriving at the proper locality about the middle of November, or from that until the 1st of December, depending upon the severity or mildness of the season; for they do not deposit their spawn until the water has reached a certain temperature, which must be something near 40° F. The fish, like some others, eat nothing during their spawning season, after which they retire to the deep water until the next spring.

The specimens of white or any other kinds of fish which inhabit our waters, as well as any information relating to their habits and varieties, will be cheerfully sent to you, when required.

You requested me to send a bill of any costs or expense incurred in sending you specimens of fish. I beg to state that there is no expense whatsoever on our part.

I have the honor to be, sir, very respectfully, your obedient servant,

PETER KIEL,
Fishery Overseer.

Professor S. F. BAIRD,
Washington, D. C.

WOLFE ISLAND, *January* 16, 1873.

SIR: I beg leave to acknowledge the receipt of your letter of 10th ultimo, which came to hand in due time, but which I did not answer immediately, in hope that the weather would moderate and that some white-fish might be taken, from which I could procure for you better defined specimens than those previously sent, which were the best I could obtain at the time, the weather being exceedingly cold and

stormy during the month of November; but unfortunately the stormy weather continued, and no white-fish were secured.

From thirty years experience as a fisherman, and after obtaining all the information possible from others on the habits of white-fish, I beg leave to remark that during the month of November the white-fish are known to unite, or join in pairs, male and female, and that they approach the shore for the purpose of spawning. Should the weather be very cold they move more rapidly and arrive at their destination about the 15th. Their favorite place is a sheltered or land-locked bay or inlet having a sandy or gravelly bottom. When in from 10 to 20 feet of water the female, endowed with an instinctive knowledge that her time has come for depositing a part of her spawn, selects a spot and commences to dig vigorously with her head, at the same time moving the tail rapidly to stir the sand or gravel; in a short time she forms a nest about two inches deep; the male, staying close by, seems to be attentively watching her movements. When the nest is satisfactorily arranged she ejects a quantity of spawn into it. The male immediately darts alongside of her and impregnates it with the milt. He then moves off a little way while she covers it partly over with her nose and tail. They remain near the spot two or three days, until all the eggs are deposited in the same nest, when they return to the deep in search of food, leaving the eggs and young fish, when hatched out, to shift for themselves. In the meantime the spawn, being heavier than water, remains on the bottom, which it would do even if not partly covered over, nature having provided an adhesive substance which fastens it to the sand or gravel. It remains about one hundred days, when the young fish emerge into life. While they were exposed for so long a time we cannot fail to admire the beautiful and mysterious laws of nature manifested in their protection from the severity of the weather, from predacious wild fowl, from voracious fish and from reptiles, which during the winter are in a semi-dormant state.

As soon as the young fish are strong enough to move off they gradually work out into the deep, where they remain three or four years, when they attain their full or average size, and move round periodically with the parent-fish to their various feeding and spawning grounds.

White-fish are very prolific, and would multiply very rapidly if not destroyed by a reckless mode of fishing. Many valuable fishing-grounds have been rendered useless by hauling seines during the breeding season, since, in such case, the parent-fish are not only destroyed, but the spawn is disturbed by the seines dragging along the bottom, so that it will not hatch. Another destructive mode of fishing is to set gill-nets across the mouths of bays or inlets, where the fish, in accordance with their habit, enter in periodically; these nets turn their course some other way, and it will be clearly understood that they are so social in their nature, that in whatever direction the main body of them incline the others are sure to follow. Our fishery laws have done much already toward the prevention of such abuses.

The white-fish is of a fine organism, and, being entirely destitute of teeth, is neither predacious nor yet very voracious in its nature, but lives on the most simple fare, which consists principally of small worms and insects that abound in great numbers among the plants and porous rocks on the bottom.

It is my candid opinion that the propagation of white-fish by artificial means would be attended with great difficulty, since when they are hatched out the trouble would be to procure food for them; but I see no serious obstacle in the way of stocking lakes or rivers where the aquatic plants and grasses closely assimilate those from whence the parent fish is taken. In such case they should be moved in the fall or early spring, since transporting them in a small quantity of water for any length of time in hot weather would be very likely to kill them.

The North American white-fish is of the most delicate structure. It is beautiful and symmetrical in form, always clean and healthy in appearance, and is free from any parasites, either internal or external. It is unsurpassed in its delicious flavor and healthy quality as an article of food by any other fish.

The greatest number of white-fish are caught during the month of July.

White-fish cannot be caught with hook and line at any season of the year.

I have the honor to be, sir, your most obedient servant,

PETER KIEL,
Fish Observer.

Professor S. F. BAIRD, *Washington, D. C.*

B—THE WHITE-FISH OF EASTERN MAINE AND NEW BRUNSWICK.

By CHARLES LANMAN.

This fish, the celebrated *attihawmeg* of the great northern lakes, so frequently described by Arctic voyagers as the most delicious of all purely fresh-water fishes, is found in considerable numbers in Lake Temiscouata, where many are taken every autumn by the French Canadians, who come over from the Saint Lawrence to fish for them, and call them *poisson pointu.* The English lumbermen call them "gizzard-fish." They are taken occasionally along the Madawaska River, and the writer has caught them with rod and line below the falls of that river, at its confluence with the Saint John, in the early part of summer. At these falls the inhabitants take about forty barrels every autumn, which are cured in pickle for winter use. The white-fish abounds in all the Eagle Lakes, at the head of Fish River, a tributary of the Upper Saint John,

and in the Saint Francis Lakes, at the stream's head. In these lakes, it is caught abundantly every autumn, by torch-light, with dip-nets. It has not been observed in any of the lakes or rivers which discharge into the Gulf of Saint Lawrence, nor yet in any of the waters of Nova Scotia.

Some years since, this fish was abundant in the Grand Lake, where the writer, in the month of May, saw great numbers taken out of gill-nets set for gaspereau, and thrown away by the fishermen as worthless. At the same time, the writer caught a number of them, with rod and line, in one of those small pieces of water connected with the Grand Lake, usually called "key-holes." It is occasionally taken in the Saint John, throughout its whole extent. In the harbor of Saint John, in spring, it has been often caught in the seines and weirs with the gaspereau, and salted with that fish, because its value was not known.

It is probable that the similar fish found in the lower part of the Saint John have strayed from the great lakes at the sources of its upper tributaries, and have been swept over the Grand Falls by some extraordinary flood; once over those falls, there is no possibility of return. The white-fish seen by the writer have seldom exceeded a pound and a half in weight; but they are taken in Lake Temiscouata of the weight of three pounds, and even more. It is an inhabitant of all the interior lakes of America, from Lake Erie to the Arctic Sea. Several Indian tribes mainly subsist upon it; and it forms the principal food at many of the fur-posts for eight or nine months of the year, the supply of other articles of diet being scanty and casual. Its usual weight in the northern regions is from two to three pounds; but it has been taken in the clear, deep, and cold waters of Lake Huron of the weight of thirteen pounds. The largest seen in the vicinity of Hudson's Bay weighed between four and five pounds, and measured twenty inches in length and four in depth. One, of seven pounds' weight, caught in Lake Huron, was twenty-seven inches long. Very recently, the writer had an opportunity of seeing some fresh specimens of the white-fish of Lake Erie, and was satisfied of their identity with the "gizzard-fish" of the Saint John and Lake Temiscouata.

During the summer, the white-fish is not seen in Lake Temiscouata, and it is then supposed to retire to the depths of that unusually deep and cold lake. In October, it draws near the shores, and ascends the Tuladi River, for the purpose of spawning. It ascends the river during the night, and, having deposited its spawn, returns as quickly as possible to the lake. It is when this fish draws near the shore, prior to spawning, that the fishery is carried on, chiefly at a little bay in Lake Temiscouata, into which the Tuladi discharges its waters. At the same time, the great gray trout (*Salmo ferox*) follows the white-fish to the shore, and preys upon it. While the nets are set for white-fish, the fishers, with torch and spear, attack and capture the *Salmo ferox*, frequently of large size; and hence this latter fish has acquired the name of *tuladi* from the river to which it is attracted by its favorite prey.

The white-fish feeds largely on fresh-water shell-fish; its stomach, in

consequence, acquires an extraordinary thickness, and resembles the gizzard of a fowl; hence its popular name of "gizzard-fish." The stomach when cleaned and boiled, is a favorite morsel with the Canadian *voyageurs.*

C—NEW SPECIES OF ARGYROSOMUS AND COREGONUS.

BY JAMES W. MILNER.

ARGYROSOMUS Agassiz.

This genus was separated from *Coregonus* by Professor Agassiz in 1850.* The principal character referred to as distinguishing it is that the lower jaw is the longer. The examination of a number of species has discovered, in addition to this character, a constant difference in the form of the supraorbital bone. In *Coregonus*, it is short and broad, and does not reach the middle of the orbit. In *Argyrosomus*, it is long and narrow, and extends considerably beyond the middle of the orbit. The premaxillaries in *Argyrosomus* are much shorter; and this character and the projection of the lower jaw make the snout more pointed than in the other group. Minute teeth are present upon the premaxillaries and tongue. Professor Agassiz refers to the latter character as if it were peculiar to this genus; but, in the dried heads of *Coregonus albus*, (not of Agassiz,) teeth are apparent on the premaxillaries.

ARGYROSOMUS HOYI Gill, (MSS.)

Argyrosomus Hoyi Gill (MSS.); Hoy, Trans. Wisc. Acad., vol. 1, p. 100, 1872.

The cisco of Lake Michigan,† not to be confounded with the cisco of Lake Ontario, is a fish frequenting the deep waters. It is taken in considerable quantities, at depths of from 30 fathoms to 70, and is the principal food of the salmon or Mackinaw trout. Specimens were sent to the Smithsonian Institution, in 1870, by Dr. P. R. Hoy, of Racine, Wis., obtained in that vicinity, from which Dr. Gill made diagnostic notes, and adopted the name of *Argyrosomus Hoyi.* In a list of species of Lake Michigan, published in the Transactions of the Wisconsin Academy of Sciences, Dr. Hoy included Dr. Gill's manuscript name.

In 1871, while prosecuting work for the United States Commission of Fisheries, I collected specimens of the species in abundance, all of which were lost in the great fire of Chicago. In 1872, I obtained them in Lake Superior, and from one of this collection the following description is made:

The differences between this species and the common "lake-herring" (*A. clupeiformis* Mitch.) are quite prominent. The orbit in the cisco is very large, encroaching a good deal upon the frontal bones. The frontals are in consequence abruptly diminished in width near the posterior edge of the orbit, and in the superior aspect of the head expose the upper border of the eye. The exposed portion of the shoulder-girdle is of less width;

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* Lake Superior: its Physical Character, &c., p. 339.

† For account of habits, see page 35.

the upper portion of the clavicle (Parker) narrows abruptly to a slender blade. The premaxillaries, though higher, project forward, so as to render the snout more acute. The snout is shorter, as is also the maxillary. The mucous tubes of the head are coarser and more prominent.

From *A. nigripinnis*, described below, it differs in having a shorter head, a more prolonged snout, slightly less length of maxillary and mandible, as well as less width of head and interorbital area.

Body compressed; deeper than in most of the species of the genus. The height of the body is less than the length of the head. The distance from the snout to the nape is but little more than the length of the mandible, (1.9 inches to 1.3 inches.) The width of the interorbital area much less than length of snout. The length of the snout more than the length of operculum. The length of the maxillary is more than the greatest width of head. The muzzle is prolonged. The lower jaw extends rather beyond the premaxillaries. The maxillary is long, reaching beyond the center of the eye. The submaxilliary is long, and of moderate width. The orbit is large. Minute teeth are present on the tongue. The preopercular bone projects backward at the lower posterior angle.

The height is .22¼ of the length;* the length of the caudal peduncle,† .16; the distance from the snout to the dorsal fin, .50; the distance from the snout to the anal fin, .71; the length of the head is .25¼; the distance from the snout to the nape is .19; the width of the head is .27¾ of length of head; the width of the interorbital area is .20¼; the length of the snout is .31; the length of the maxillary is .35; the length of the mandible is .51½; the diameter of the orbit is .24.

Br., 9; D., 3–10; A., 2–10; C., 9–18–8; P., 15; V., 11; scales on lateral line, 73; number of rows of scales above lateral line, 8; below lateral line, 12. Length, 11.7 inches.

National Museum, No. 10756. Locality, Outer Island, Wisconsin, Lake Superior.

ARGYROSOMUS NIGRIPINNIS Gill, (MSS.)

Argyrosomus nigripinnis (Gill, MSS.); Hoy, Trans. Wisc. Acad. Sc., vol. 1, p. 100, 1872.

The black-fin ‡ is not known from any locality thus far other than Lake Michigan. It is found in the deepest portions of the lake, and is especially abundant in Grand Traverse Bay. Specimens were received at the Smithsonian Institution from Dr. Hoy, in 1870. The only species closely related to it is the one just described. From this it differs in the shorter head, snout, maxillary, mandible, and the greater width of head and interorbital region. There is a greater number of scales in the lateral line; the fins are more developed; and the height of the fish is slightly greater. It attains a much greater weight than *A. Hoyi;* its average

* Measured from premaxillaries along lateral line to end of scales.

† Measured from a point vertical to the last ray of the anal fin.

‡ For reference to habits, see page 35.

being about one and a fourth pounds, while *A. Hoyi* reaches a maximum of less than one-half pound.

The height of the body is equal to the length of the head. The distance from the snout to the nape is much more than the length of mandible, (2.28 inches to 1.52 inches.) The width of the interorbital area is equal to the length of the snout. The length of the snout is less than the length of the operculum. The length of the maxillary is less than the greatest width of the head.

Body compressed; deeper in proportion to length than other species of the genus. The bones of the head are stronger and more prominent than in other species; mucous tubes on preoperculum, on frontals, and parietals large and prominent.

Teeth very minute, yet present on premaxillaries and tongue.

The height is .22 of length; the least height of tail is .07$\frac{3}{4}$; the length of the caudal peduncle is .13$\frac{1}{2}$; the distance from the snout to the dorsal fin is .47$\frac{1}{5}$; the distance from the snout to the anal fin is .78$\frac{1}{2}$; the length of the head is .22$\frac{5}{8}$; the distance from snout to the nape is .16$\frac{3}{4}$. The width of the head is .34$\frac{3}{4}$ of the length of the head; the width of the interorbital area is .22$\frac{1}{5}$; the length of the snout is .22$\frac{1}{2}$; the length of the maxillary is .32; the length of the mandible is .48$\frac{1}{2}$; the diameter of the orbit is .25$\frac{1}{2}$.

Br., 9; D., 3–10; A., 2–10; C., 10–18–9; P., 16; V., 12; number of scales in the lateral line, 80; number of rows of scales above lateral line 8; below lateral line, 11. Length, 16.5 inches.

National Museum, No. 12455. Locality, Grand Haven, Mich., Lake Michigan.

3.—Coregonus Couesii, *sp. nov.*

A specimen of a white-fish was taken in Chief Mountain Lake, at the eastern edge of the Rocky Mountains, by Dr. Elliott Coues, U. S. A., surgeon and naturalist of the northern-boundary commission.

This specimen is very different in its type of form from any species hitherto described from this continent. In Günther's arrangement of the species of *Coregonus*, it would be placed in group (α), with the upper jaw produced into a cutaneous appendage. In this particular, it resembles *Coregonus oxyrhynchus* Lin. and *C. Lloydii* Günth. Unlike these species, it is an elongate fish, the proportion of height to length being much the same as in *C. Williamsoni* Gir. and *C. quadrilateralis* Rich.; it also resembles this type of form in the narrow supplementary bone of the maxillary, and the former species in the shape of the maxillary.

The only previous reference to a fish supposed to be of this genus from the Saskatchewan River is in some remarks appended to the description of *C. labradoricus* in the *Histoire Naturelle des Poissons*. Valenciennes refers, in the most undecided manner possible, to a fish which he believes to be a salmonoid, and makes his diagnosis from a drawing. There is, in fact, no direct evidence in what he says to prove that the specimen was in his possession. He admits that he is "not able to

determine with certainty the genus;" and, after stating that "my first impression was to make it a *Coregonus*, since I have placed the design by the side of the other species of the same genus," ends this most uncertain and undecided effort to determine its relationship with the question, "Could one name it *Coregonus angusticeps?*"

It may be that the specimen at hand is a fish of the species indicated in the above name, the ascribed locality heightening this possibility; but there can be no consideration of the matter that will decide it, and the name is consequently passed over. The character given of 55 scales in the lateral line is very far from agreeing with Dr. Coues's specimen, and, in fact, with any description of a *Coregonus* we have seen, and may indicate that the author was right in his hesitancy to decide upon the genus.

The most marked feature is the extensive prolongation of the snout, which protrudes far beyond the opening of the mouth. The head narrows regularly toward the anterior of the frontals, where two strong angles are found narrowing the head abruptly at the point where the short supraorbitals join, and the frontals and nasals continue forward in a narrow, blade-like extension. The supraorbitals form a bold prominence at the anterior of the orbit. The maxillary is short, dilated at its posterior portion, and has a narrow supplementary bone. The pre maxillaries are somewhat retroverted, and have very little width, making the muzzle thin and narrow, as it is in *C. quadrilateralis* and *C. Williamsoni.* The adipose fin is large, attached to the body almost to the posterior extremity, and is ensheathed in scales for a considerable distance from the dorsal line.

The greatest height of body is equal to the length of the head. The least height of tail is equal to the length of the snout. The lengths of the caudal peduncle, of the snout, and of the mandible are equal to each other. The width of the interorbital area is equal to the length of the maxillary.

The height is .22½ of the length without the caudal; the least height of tail is .07½; the length of the caudal peduncle is .12½; the distance from the snout to the dorsal fin is .44¾; the length of the base of the dorsal fin is .12½, its greatest height .14, and the length of the last ray .06⅔; the distance from the snout to the anal is .73⅓; the length of its base, .09, and its greatest height .13⅓; the length of the middle caudal rays is .08, and of the external rays .15¼; the distance from the snout to the pectoral fin is .21½, and its length is .17½; the distance from the snout to the ventrals is .51½, and its length is .15.

Br., 9; D., 3–12; A., 4–10; C., 6–18–6; P., 17; V., 2–11; the number of scales in the lateral line is 88; the number of scales above the lateral line is 8; below the lateral line, 8–5. Length, 13.6 inches.

National Museum, No. 14146. Locality, Chief Mountain Lake. Collector, Elliott Coues, U. S. A., surgeon and naturalist of the northern boundary commission.

APPENDIX B.

THE SALMON AND TROUT.

(SPECIES OF SALMO.)

III.—ON THE NORTH AMERICAN SPECIES OF SALMON AND TROUT.

BY GEORGE SUCKLEY, SURGEON, UNITED STATES ARMY.

(*Written in* 1861.)

NOTE.—The late Dr. Suckley made a special study for some years of the North American *Salmonidæ*, his attention having been specially called to them by the number of species met with in his journeys across the northern part of the United States to the Pacific coast while serving as naturalist to the Pacific Railroad Survey, under Governor Stevens, and while stationed as surgeon at Western military posts.

A report was prepared by him on this subject in 1859, forming part of the twelfth volume of the series of Pacific Railroad Reports, and was reproduced in a separate volume entitled "The Natural History of Washington Territory," by Dr. J. G. Cooper and himself.

After the return of the Northwestern Boundary Survey, in 1861, he was intrusted by the Commissioner, Mr. Archibald Campbell, with the preparation of a report on the *Salmonidæ* of Washington Territory, which he completed, although it was never published, and which Mr. Campbell, by permission of the State Department, kindly turned over to the Smithsonian Institution to dispose of as it might think proper.

At the request of the Smithsonian Institution, Dr. Suckley then enlarged this report by the addition of other species of North American *Salmonidæ*, thus making a second and much improved edition of his first memoir, embracing, as it did, the large amount of material belonging to the Institution, among the most important of which was that collected in the Hudson Bay territory by Mr. Kennicott and other correspondents.

This memoir was delivered to the Institution in July, 1861; and, although in the thirteen years which have elapsed, much change has taken place, in our knowledge of the subject, still, on account of the completeness of the paper, and the absence of anything more full on the subject, I here introduce it, by permission of the Secretary of the Smithsonian Institution, in its original form.

Whatever be its defects or redundancies, it will serve as an excellent basis for further investigation; and although it is probable that the actual number of species is less than that given by Dr. Suckley, who doubtless considered certain variations of age, sex, and season as species, it will be easier to reduce them to the proper number after the publication of this report.

S. F. BAIRD.

Although a great many divisions have been established for the species of the old Linnæan genus *Salmo*, for the purposes of the present report it will be sufficient to consider them all as one, only recognizing a separate section of *Oncorhynchus*, for the sea-salmon with permanently hooked bill. For convenience, however, we may arrange them as follows:

I. Anadromous salmon. Species running up into fresh water to spawn; the young remaining there for a greater or less time, then returning to the sea, in which they continue to abide, except during the period of reproduction. (Salmon.)

a. Intermaxillaries of the fresh-run adult male fish or those just from the sea, long, decurved, projecting and hooking downward considerably beyond the top or knob of the lower jaw; well armed with strong teeth; the extremity of the lower jaw terminating in a broadly dilated knob, similarly armed with strong, hooked teeth. (The subgenus *Oncorhynchus*, Suckley.)

1. *Salmo scouleri*, RICHARDSON.—Hook-nosed salmon; fall salmon, (Pacific coast.)
2. *Salmo proteus*, PALLAS.—Hump-backed salmon. (Alaska coast.)
3. *Salmo cooperi*, SUCKLEY.—Cooper's salmon. (Columbia River.)
4. *Salmo dermatinus*, RICHARDSON.—(Bering Sea.)
5. *Salmo consuetus*, RICHARDSON.—(Yukon River.)
6. *Salmo canis*, SUCKLEY.—Dog salmon; spotted salmon. (Puget Sound.)

b. Jaws of adult males when fresh-run, symmetrical, and either subequal or the point of the lower jaw received in a notch between the premaxillaries.

† Without red spots; not feeding in fresh water, except from caprice.

7. *Salmo salar*, LINNÆUS.—The common salmon. (North Atlantic.)
8. *Salmo quinnat*, RICHARDSON.—The California salmon. (west coast of the United States.)
9. *Salmo confluentus*, SUCKLEY.—Towatl salmon. (northwest coast.)
10. *Salmo aurora*, GIRARD.—Red-char; Salmon. (Columbia River.)
11. *Salmo argyreus*, GIRARD.—(West coast.)
12. *Salmo paucidens*, RICHARDSON.—Weak-toothed salmon. (Fraser River.)
13. *Salmo tsuppitch*, RICHARDSON.—White salmon. (Columbia River.)
14. *Salmo clarkii*, RICHARDSON.—Clark's salmon. (Columbia River.)

15. *Salmo immaculatus*, STORER.—The unspotted salmon. (Labrador.)
16. *Salmo gairdneri*, RICHARDSON.—Gairdner's salmon. (Columbia River.)
17. *Salmo truncatus*, SUCKLEY.—The short-tailed salmon. (Columbia River.)
18. *Salmo richardi*, SUCKLEY.—Richard's salmon. (Fraser River.)

†† Spotted with red; feeding freely in fresh water.

19. *Salmo campbelli*, SUCKLEY.—Campbell's salmon. (Columbia River.)
20. *Salmo hudsonicus*, SUCKLEY.—Hudson's Bay trout.
21. *Salmo rossii*, RICHARDSON.—Ross' salmon. (Arctic Ocean; Boothia Felix.)
22. *Salmo hearnei*, RICHARDSON.—Coppermine salmon. (Coppermine River.)
23. *Salmo alipes*, RICHARDSON.—Long-finned Char. (Lakes of Boothia Felix.)
24. *Salmo nitidus*, RICHARDSON.—The angmalook. (Lakes of Boothia Felix.)

II. Species not anadromous, nor running up from the sea, but living entirely in fresh water or only occasionally passing down to the sea. (Trout.)

c. Spotted with red or black; found in flowing fresh water; feeding, spawning, and spending the greater part of the year in the same; retiring to deep, still water in the winter; access to salt water usually relished, but not indispensable.

† Red-spotted.

25. *Salmo fontinalis*, MITCHILL.—The American brook-trout. (Eastern States.)

†† Black-spotted.

26. *Salmo iridea*, GIBBONS.—Pacific brook-trout. (California streams.)
27. *Salmo masoni*, SUCKLEY.—Mason's trout. (Columbia River.)
28. *Salmo virginalis*, GIRARD.—Utah trout. (Southern Rocky Mountains, Utah; New Mexico.)
29. *Salmo lewisi*, GIRARD.—Missouri trout. (Rocky Mountain slopes north of South Pass.)
30. *Salmo brevicauda*, SUCKLEY.—Short-tailed trout. (Puget Sound waters.)

d. Trout found in deep rivers or lakes, ascending shallow streams to spawn.

† Black-spotted.

31. *Salmo gibbsii*, SUCKLEY.—Columbia salmon trout. (Columbia River.)
32. *Salmo sebago*, GIRARD.—Sebago trout. (Sebago Lake, Maine.)
33. *Salmo kennerlyi*, SUCKLEY.—Kennerly's trout. (Chiloweyuck Lake; Fraser's River.)
34. *Salmo warreni*, SUCKLEY.—Warren's trout. (Fraser's River.)

†† Red-spotted.

35. *Salmo bairdii*, SUCKLEY.—Baird's trout. (Clark's Fork of the Columbia.)
36. *Salmo parkii*, SUCKLEY.—Parker's River trout. (Kootenay River, Rocky Mountains.)
37. *Salmo oquassa*, GIRARD.—Blue-back trout; Oquassa. (Rangeley Lake, Maine.)

e. Lake trout, passing their lives in deep, fresh water lakes, approaching the shores annually to spawn in shallow water; never entering running brooks or repairing to the sea.

38. *Salmo namaycush*, PENNANT.—Mackinaw trout. (Great Lakes.)
39. *Salmo confinis*, DEKAY.—Lake trout. (Lakes of New York.)
40. *Salmo siscowet*, AGASSIZ.—Siscowet. (Lake Superior.)
41. *Salmo symmetrica*, PRESCOTT.—Winnipiseogee trout.
42. *Salmo hoodii*, RICHARDSON.—Hood's salmon. (Lakes of Atlantic slope, north of Canada.)
43. *Salmo newberryi*, GIRARD.—Newberry's salmon. (Klamath River.)

1. SALMO SCOULERI, Richardson.

SKOWITZ; HOOKED-NOSED SALMON; FALL SALMON.

SYN.—*Salmo scouleri*, RICH. Faun. Bor. Amer. iii, 1836, pp. 158 and 223, Pl. 93; DEKAY, N. Y., Fauna iii, 1842; GIRARD, Gen. Rep. Fishes, p. 305; HERBERT, Fish and Fishing, &c., Suppl., p. 37, 1850; SUCKLEY, Nat. Hist. Washington Territory, p. 335.

Salar scouleri, VALENC. in CUV. and VAL. Hist. Nat. Poiss. xxi, pp. 242, 345, 1848; STORER, Synops, p. 194, 1846; GRD. in Proc. Acad. Nat. Sc., Philad. viii, p. 217, 1856.

? *Salmo consuetus*, RICH. Zool. Voy. Herald, Plate xxxiii, 1854.

? *Salmo lycaodon*, PALLAS, Zoogr. Ros. Asiat.

Oncorhynchus scouleri, SUCKLEY, "Notices of a Species Salmon," &c., N. Y. June, 1861.

SP. CH.—*Male.*—Profile much arched, the convexity rising from nape to dorsal fin. The body at that point is thick, tapering from thence to

the caudal. Intermaxillary prolongation strongly decurved, and armed with large hooked teeth. Under jaw armed with a dilated and slightly incurved knob, similarly provided with strong teeth. The teeth on the sides of both jaws are strong, and very irregular in size or disposition, and extend almost to the angle of the commissure. Teeth on the vomer, present or absent, varying in this respect in different specimens. Caudal fin moderately lunated, the degree varying according to age.

Colors.—In recent specimens fresh from the sea we find a silvery luster; not, however, as strongly marked as in the *S. gairdneri*, *S. quinnat*, and other species. The ground-color of the back is lead-color or a silvery blue, and that of the belly white or yellowish white. The back and sides, dorsal fin, and tail are unspotted.

Female.—The fresh run females differ in having symmetrical jaws, destitute of elongated intermaxillary, or of the incurved knob on the lower jaw.

DIAGNOSIS.—The male may be known from all but the other hook-billed species by having the long decurved intermaxillaries and cartilaginous snout extending considerably beyond the point of the lower jaw; by its large irregular teeth on the maxillaries: From the *S. proteus* and *S. dermatinus*, by having less of a dorsal hump; by the marked lapping of the scales, and by having an unspotted caudal fin. The teeth along the maxillaries are also not awl-shaped and uniform as in *S. proteus*, being more frequently alternately large and small. They are also less numerous. The female may be recognized from those of most of the other species.

HABITAT.—Pacific coast; anadromous; enters fresh-water rivers in autumn.

Spec. 1129 Smiths. Coll. has a less number of rows of scales both above and below the lateral line, than has No. 1130. This may be owing to sex, or perhaps species. In many respects the fish agree very well. No. 1130, however, has the tongue and vomer toothless. May not this be the result of age? If not, and the fish prove to be distinct, which shall be considered new? or which *S. lycaodon*, Pallas, *S. consuetus*, Rich., or *S. scouleri*, Rich?

It would be very easy to take up one of these specimens and impose a name upon it, and, ergo, an additional incubus upon the study of the family. But I refrain. A few years will probably bring us plenty of specimens from the waters of the North Pacific, on both sides. Then, and not till then, can the synonymy of the hooked-snout, big-toothed, and round-backed species be properly determined. This is an exceedingly abundant species on the northwest coast, and affords the principal salmon harvest to the Indians, who dry vast numbers for winter use. It usually commences to run up the streams which empty into Puget Sound about the first week in September, and continues to arrive until near Christmas. During the months of January, February, and March, they are found abundantly in small shallow brooks and streams tributary to the larger

rivers. At this late period they are much emaciated, owing to their exhaustion from breeding and from months of abstinence, they being said not to eat after entering fresh water; and their flesh, when cooked, is rank and ill-flavored. During the month of April they suddenly disappear, probably returning by the spring floods to salt water, although the Indians say that but few return to the sea. The flesh of this fish, when fresh from salt water, the individual being fat and in good condition, is of a very pale yellowish "salmon" color. This color soon changes to a pinkish-yellow, and, when the fish is worn out, to yellowish-white.

The males of this species have the hooked snout while still in salt water and in good condition. In this difference of the jaws in the sexes they agree with the *S. hamatus* of Lapland, which, according to the author of the "Lachesis Lapponica," has the hooking of the lower jaw confined to the male sex. (See quotation in Rich. F. B. A.)

The female *skowitz* when fresh run has symmetrical jaws. The snout becomes slightly decurved when they are much emaciated, and is simply owing to the absorption of the fatty cushions along the intermaxillaries, and therefore more apparent than real.

The *skowitz* runs in immense shoals up the rivers emptying into Puget Sound. Fisheries have been established in certain localities, and as many as 3,000 fish taken in one haul of the seine.

Since writing the report for the Pacific Railroad survey, so frequently alluded to in this monograph, I have been further convinced that Dr. Gairdner, whose notes are quoted by Sir John Richardson, confounded the *Salmo proteus* and the present species, and recorded notes, part of which apply to one and part to the other. The flesh of this fish, although inferior to *S. quinnat*, *S. gairdneri*, and *S. truncatus*, is far better than of the other autumnal kinds. Being of a convenient size, they are rather preferred for packing in salt.

After entering the Columbia the *skowitz* ascends the current of the main river and its tributaries to points fully seven hundred miles by water from the sea.

The Indians say that many individuals return to the sea. According to the natives at Fraser River, the present fish after entering salt water changes color in a very uniform manner, the males turning red, the females black. It, as well as *S. canis*, enters Chiloweyuck Lake.

On the 4th of October, 1859, George Gibbs, esq., obtained from the Okanagon River, Washington Territory, a female of this species, (No. 2007 Smith. Collect.,) which he says is the kind known to the Indians of that region as the *ka-shoo*, (*ke-as-soo*, or *ka-ka-soo*, McDonald.) (See chap. on Salmonidæ, Cooper & Suckley, Nat. Hist. Washington Territory.) According to Mr. Gibbs, the length of his specimen was 27 inches; head, 5.75; lateral line, 18; distance from snout to ventrals, 13.50; to dorsal, 10.60; to adipose, 18.75; to anal, 17.75; meat, red; eggs, orange; size of beaver, short. It had just arrived in the river.

The species was not yet quite ready to spawn, and does not do so till after the *ta-ah-nia*, (*S. cooperi.*) A specimen in Dr. Kennerly's collection appears to be that of a female of this species, taken from the salt water when in prime condition. It was obtained at New Dungeness, Straits of Fuca, in August, 1857, and was called by the Indians of that locality the *kutsh-kuss*, the name they are known to apply to the *S. scouleri.* There is nothing remarkable about the specimen except its bright silvery appearance, which, however, the species always has while yet in the salt water. It has also 14 to 15 branchiostegals, one more than is usual. In a paper entitled "Notices of certain New Species of North American Salmonidæ," published by the writer in June, 1861, I proposed a distinct sub-genus for the group of salmon embracing this species, the *S. scouleri*, *S. proteus*, and *S. cooperi*, in which the adult males have the premaxillaries considerably elongated, and the tip decurved, extending considerably beyond the extremity of the lower jaws where there exists a knob at the extremities more or less broad, and heavily armed with strong curved teeth, as are the premaxillaries above.

The type of this sub-genus (which I designate as *Oncorhynchus*) is the *Salmo scouleri* of Richardson. If my separation of this group from the other salmon is considered as based on sufficiently good anatomical differences, the species above mentioned will hereafter be known as *Oncorhynchus scouleri*, *Oncorhynchus cooperi*, *Oncorhynchus proteus*, *Oncorhynchus dermatinus*, *Oncorhynchus consuetus*, and *Oncorhynchus canis*. In the latter species the projection of the intermaxillaries beyond the lower jaw is not so strongly marked, but the broad knob and the heavy armature of strong teeth on both that and the premaxillaries exist.

2. SALMO PROTEUS, Pallas.

HUMP-BACKED SALMON.

Specimen in Smithsonian collection Fishes, No. 1132.

SYN.—*Salmo proteus*, PALLAS, Zoog. Ros. Asiat. iii, p. 376; VALENC. in CUV. and VALENC. Hist. Nat. Poissons, xxi, p. 360, 1848; SUCKLEY, Nat. Hist. Wash. Territory, p. 339, 1859; IBID., P. R. R. Repts., vol. xii.

Salmo gibber, SUCKLEY, Ann. N. Y. Lyceum Nat. Hist., Dec., 1858.

Salmo dermatinus, RICH., Voy. of Herald, 1854.

Oncorhynchus proteus, SUCKLEY, Notices of Certain New Species of Salmon. N. Y., June, 1861.

Gorbuscha of Kamtschatka; *Hunnun* of the Lummies; *Huddoh* of the Nisquallies.

SP. CH.—*Male.*—Dorsal profile much more arched than in *S. scouleri*, Rich. After entering fresh water, an adipose hump becomes strikingly apparent, its greatest prominence being nearly opposite a point midway on a line drawn from the eye to the anterior margin of the base of the dorsal fin; intermaxillary projection curved strongly downward, as in *S. scouleri*; jaws long, as in latter, the latter terminated by a dilated knob, (as in several other species of the genus,) which is armed with four

or five strong, sharp teeth on each side; labials and limbs of the lower jaw closely set with very fine, sharp teeth, finer and more numerous than those of the *S. scouleri;* vomerine and palatine teeth much larger than those of the labials; those of the vomer disposed in a single row on its anterior portion; tail rather strongly lunated, and profusely dotted with large, elongated, oval, dark spots; the other fins usually unspotted, adipose rather elongated; scales much smaller than those of the *S. scouleri* and very thin. They are imbedded in the skin and do not lap over, and in many parts of the body do not even touch each other; those of the back are much smaller than those below the lateral line. Skin very thick.

HAB.—The Northern Pacific coasts of Asiatic Russia and America; Puget Sound. Said not to enter the Columbia or to be seen south of the Straits of Fuca.

DIAGNOSIS.—The present species may be distinguished from the *S. scouleri* by its smaller size, the prominent hump in the males, its smaller scales, spotted tail, and the fine regular teeth along the sides of the jaws. The teeth of the *S. scouleri* are scattered irregularly, and are generally large, but by no means uniform in size along the sides of the maxillaries. The *female* is shaped much like a shad. The spots on the caudal of specimen 1132 are larger in proportion than those found on the tail of any salmon of which examples from the northwest coast are contained in the Smithsonian collection. But two hump-backed salmon have thus far been received from the northwest coast, both obtained by Dr. Kennerly, and both described in Vol. X, Pacific Railroad Reports. The condition of the skins before us does not well admit of a satisfactory demonstration whether the smaller scales along the abdomen and near the tail do not overlap each other; but the fact that they do not even touch each other on the back and sides is apparent. It is very probable that the salmon described by Richardson, (and included in the present monograph,) *S. dermatinus*, is identical with the *Proteus*. (See S. DERMATINUS.)

One of Dr. Kennerly's specimens has a smooth, toothless tongue; the other, a female, has a single tooth thereon. The colors of this species, like those of all anadromous salmon, become greatly changed after entrance into fresh water. Those of the male sent by Dr. Kennerly had "the head greenish-yellow, clouded with black; opercula, dull pinkish; upper parts, dirty grayish and yellow; ventrals and pectorals, grass-green; dorsal, ultramarine and green; tail, blotched with black."

There are two specimens of the true hump-backed salmon of the northwestern coast in the Smithsonian collection. The writer described them as new, under the name of *Salmo gibber*, in the annals of the New York Lyceum, December, 1858; but upon further examination, and a careful comparison with Pallas's description of *Salmo proteus*, he become convinced that it refers to the same fish. Upon comparing the same specimens with Richardson's account of *S. dermatinus*, a similar identity of

resemblance is manifest. The Smithsonian specimens 1132, 1133, (male and female,) are described as *S. proteus*. The male agrees remarkably with Richardson's figure. The tongue is smooth; tail of the same shape; fin membranes very thick; skin ditto; scales very small and imbedded in the skin; except on the abdomen, perhaps; they do not lap or even touch each other. No. 1132 has been drawn and figured for the present work. The hump seems greater than in the *S. dermatinus*.

The female has a single tooth on the tongue. May not the toothless tongue be a mark of old age?

For the present it is thought best to retain the species under Richardson's name, and wait for more specimens of salmon, not only from Arctic America and the vicinity of Vancouver's Island, but also from Kamtschatka, before deciding the question of names and synonyms.

The average weight of the fish is about 5 or 6 pounds. Its flesh is pale, and for a white man, it is poor eating. The Indians say that this salmon is usually quite fat, and that as food they like it very much. They state that it enters Puget Sound and the rivers on alternate years, it being very rare for even a single individual to be caught in the intermediate season. The run of the *huddoh* in its regular years is large, coming in vast numbers, comparing favorably in this respect with the *satsup*, *skowitz*, or *h-hwhai*. According to the natives of our coast, the *hunch-back* never returns to the sea after spawning, but dies in fresh water. In this respect they again agree with the Kamtschatka fish.

In our opinion this is undoubtedly the *gorbuscha* of Kamtschatka, mentioned by Pallas and referred to by Sir John Richardson.

The *hump-back* enters the rivers about Puget Sound in August of alternate years. It is thought that it does not visit the Columbia River. The hump of the male is said to be caused by a thick layer of adipose matter.

For additional facts and extended quotations the reader is referred to the Pacific Railroad Reports, vol. xii, p. 339.

3. SALMO COOPERI, Suckley.

COOPER'S SALMON; THE TA-AH-NIA.

SYN.—*Salmo cooperi*, SUCKLEY, Notices N. S. N. Am. Salm. N. Y., June, 1861.
Oncorhynchus cooperi, SUCKLEY, op. cit.
The *Ta-ah-nia* of the Okina Kanes.

SP. CH.—*Male.*—Head enters nearly four and one-quarter times in the total length. Back much arched, having a tendency to hump. Scales rather coarse and large. Skin thick and strong. Tail deeply lunate; profusely sprinkled with oval spots of black. Snout (premaxillaries) somewhat elongated. Dental development much like that of *S. proteus*, Pal., but the fish differs in lacking the exaggerated hump, and in the lapping of the scales on the body. The adults rarely exceed 22 inches.

Female.—Of similar size; mouth symmetrical; back less arched; teeth

developed much as in the female *S. scouleri*. In both sexes there are usually thirteen branchiostegal rays on a side.

DIAGNOSIS.—From *S. proteus*, Pal., by the comparatively small hump, by its smaller size, and by its proportionately larger scales. From the *S. scouleri* it may be known by its smaller size, spotted tail, and small uniform teeth along the bodies of the maxillaries.

HAB.—Anadromous, ascending the Columbia in autumn. Found exceedingly abundant in Okina-kane River, where it is known to the whites as the "little red salmon," and to the natives as the *ta-ah-nia.*

This species, which we have named after Doctor James G. Cooper, who has spent much time investigating the natural history and physical geography of Washington Territory, was obtained by George Gibbs, esq., at the Okina-kane.

S. cooperi. Two specimens (typical) were obtained by Mr. Gibbs.

"Okina-kane River, September 30, 1860. This fish is now drawing to its spawning season. It frequents this river and the lakes above in immense numbers, its peculiar color actually reddening the bed of the river.

"MEASUREMENTS.—*Male.* Length, 21.75 inches; head, 5; to dorsal fin, 10; to ventral, 10.50; to anal, 14; to adipose, 16. Upper line of head very concave; iris, yellow; body, brick-red; near the tail, scarlet; caudal brown, profusely speckled with black. *Female.* Length, 22 inches; head, 4.50; to dorsal, 10; to ventral, 11; to anal, 14.75; to adipose, 16.75.

"*Colors.*—Head, light greenish; back, brick-red, inclining to purple; belly, dirty, yellowish gray; caudal, speckled; upper line of the head convex—the reverse of that of the male; eggs red and of the size of swan-shot; caudal but slightly lunated.

"The fish measured above appear to be about the average size of adults."

4. SALMO DERMATINUS, Richardson.

SYN.—*Salmo dermatinus*, RICH. Zool. of the Voyage of the Herald, p. 169. Pl. xxxiii. London, 1854,

? *Salmo proteus*, RICH.

? *Salmo gibber*, SUCKLEY, Annals N. Y. Lyceum.

Oncorhynchus dermatinus, SUCKLEY, "Notices of Certain New Species of the Salmonidæ," &c. N. Y., June, 1861.

SP. CH.—(Condensed from Richardson's description.) Tongue, toothless; seven or eight teeth on each premaxillary, unequal; one or two at the tip larger than the others, recurved. Maxillary armed with 18 to 21 acute subculate teeth, the first being stoutest, third and fifth next in size. Dilated knob on end of lower jaw, armed with strong teeth. This meeting the incurved snout (in males only ?) prevents the closing of the mouth. Scales do not overlap each other, but are imbedded in a thick

muciferous epidermis, and do not even touch each other. Branchiostegals 14 to 15. Tail strongly cut out.

HAB.—Ascends the rivers emptying into Behring's Sea. A single specimen of this salmon, about 32.4 inches in total length, was obtained by Sir John Richardson from the Yukon River in Arctic America. It is there known to the fur hunters as the *red-fish*. Sir John says it is very distinct from any of the European anadromous salmon. It is called by the Kutchin tribe *tleukh-ko*. They take it by weirs constructed between island and island, and by spearing. The flesh and roe are dried for winter use, and the tough skins are made into clothing. (Vide Richardson, op. cit.)

5. SALMO CONSUETUS, Richardson.

SYN.—*Salmo consuetus*, RICH., Voyage of the Herald, London, 1854, p. 167, Plate. xxxiii.
? *Salmo collaris*, PALLAS, Zoogr. Ross. As.
? *Salmo lycaodon*, PALLAS, op. cit.
? *Salmo scouleri*, RICH. Faun. Boreal. Am., pp. 158 and 223, pl. 93.
Oncorhynchus consuetus, SUCKLEY, "Notices of N. S. Salm.," N. Y., June, 1861.

SP. CH.—Drawn from Richardson's description and probably applicable to an exhausted or emaciated male. General form that of *S. salar* when out of season, but smaller. Head disproportionately large; jaws distorted. Length of head (when measured from tip of snout to distal margin of operculum) contained four and two-third times in the total length of the fish. Cartilaginous snout decurved and extending considerably beyond the mandibles. Five or six rather large teeth on each premaxillary. Scales smaller than those of *S. salar*, but resemble them in delicacy of luster, and the ease with which they can be detached. Tongue armed with two parallel rows of teeth, six on each side. Dorsal outline strongly arched. Tail lunated.

HAB. 7.—Yukon River, Arctic America; ascends as high as the falls of the Porcupine.

Sir John Richardson drew his description from a male about 23.5 inches in total length. In this the scales in size compared to those of *S. salar* were smaller, as 12 or 13 to 10 on patches of skin of equal size; 140 scales on lateral line. Fin membranes quite thick. Rays Br. 12–13; D. 11–0: A. 15; C. $1\frac{1}{18}$: P. 14 or 15: V. 9–9, or 10–10.

6. SALMO CANIS, Suckley.

DOG SALMON; SPOTTED SALMON; LE KAI.

SYN.—*Salmo canis*, SUCKLEY, Annals N. Y. Lyceum, Dec., 1858; IBID. Pacific R. R. Reports, vol. xii, part Fishes, p. 341. [The sp. ch. given in vol. xii., P. R. R. Reports and in the original description were written from memory. Luck-

ily since then Dr. Kennerly has sent home a fine skin and one or more heads;] IBID. Nat. Hist. Wash. Terr., chap. on Salmonidæ.

Oncorhyncus canis, SUCKLEY, Notices of Certain New Species N. A. Salmonidæ. N. Y., June 15, 1861.

SP. CH.—Head large; contained about $4\frac{1}{2}$ times in the total length; its dorsal outline nearly straight; a dilated knob on the extremity of lower jaw, upon which there are usually at least three large curved teeth, the anterior being the largest. Large curved teeth on the premaxillary; arms of the jaws studded with small teeth of nearly uniform size and appearance. Tongue with a diverging row of four teeth on each side. Nostrils large and pyriform. Free margin of opercula rounded much as in *S. salar;* average number of branchiostegals, 13. Skin thick, fleshy; fin membranes ditto. Scales quite adherent and over-lapping each other about one-third. General form of body, compressed laterally, causing it to be a rather deep fish for its size and weight; dorsal outline only moderately arched; caudal insertion rather deep, caudal furcate.

Colors.—Skin unspotted (*i. e.*, without speckles) but blotched on the sides (especially after being a few days in fresh water) with large patches of dingy-green and purplish-red. Fins and tail unspeckled.

DIAGNOSIS.—The *Salmo canis* is known from the *S. scouleri* by the greater equality of its jaws; by its shorter intermaxillaries; by the short, small, pointed, nearly uniform awl-like teeth on the bodies of the inferior maxillaries. From the humped species it can readily be recognized. Like the *S. scouleri* it has an unspotted tail.

HAB.—Northwestern coast of America; enters the streams along Puget Sound in great numbers in autumn.

The mouth of the female, as is usual with this group or subgenus of salmon, is much more symmetrical than that of the male.

The dried skin of a female salmon was obtained by Mr. George Gibbs at New Dungeness, Straits of Fuca, August 12, 1857. It is now catalogued in the Smithsonian Museum as No. 1128. At first we took the specimen to be a female *S. scouleri*, but more careful examination showed our error. It more nearly approaches the *S. canis* and is probably the female.

Mr. Gibbs says it was known to the Klallams as the *ket-hlehts*. In the alcoholic specimen before me, the adipose fin is much elongated; its anterior (or upper) margin much curved. The jaws are about equal in length, but owing to the long teeth anteriorly they could not be made to close tightly—the nearest approach to perfect closure being when the under jaw was diverted to the right or left of its true line, like a pair of tongs, in which the extremities pass each other owing to a defect in the joint.

There are also two teeth felt near the middle of the vomer, one before the other. The jaws nearly equal in length, the lower being barely received in the upper.

The following quotation from our former report contains all the information recorded concerning the habits of the fish:

"The *spotted* or *le kai salmon* enters the rivers of Puget Sound in great numbers every autumn, generally appearing between September 15 and October 10. They come in vast numbers, and arrive so simultaneously as to seem to be in shoals, though, probably, that is occasioned, not by a gregarious habit, but by the same instinct causing all the individuals to leave the sea at about the same period for the purpose of procreation. They are not a finely flavored fish, even when "fresh run," many individuals being at that time in bad condition—a condition unusual among salmon just quitting salt water. After a short residence in fresh water, all become poor and unsavory, and some even intolerably rank. Upon first arrival the sickly fish are readily distinguished by the natives by their colors, the best fish being of a leaden-olive or dingy-green on the back, and a yellowish-white along the belly. The poor ones are of various shades and tints of dingy-green and yellow, more or less maculated on the sides with purplish and black blotches. They enter by preference the smaller streams. Owing to the large jaws and long ferocious-looking teeth of the species, they have obtained from the whites the name of dog-salmon. Vast numbers are taken by the Indians with spears, gaff-hooks, weirs, &c., and dried for winter use. Upon their arrival in September and October their roes are nearly mature. It is interesting to witness their persevering efforts to run up shallows, and in overcoming insurmountable obstacles, even running out of water upon the shores in their blind eagerness to surmount impossibilities and reach the head-waters of the stream to deposit their spawn. In endeavoring to ascend high falls, and in passing through rocky, violent passages, their snouts and bodies become much bruised and injured, giving rise to sores and ulcerations. The fins become much worn, also. The impoverished fish have hooked snouts and pale whitish flesh. At no time is it seen with the bright salmon-red flesh common to other kinds; but on the first arrival, when in good order, they are found with flesh which, when cooked, has a pinkish-buff color, and is not, in my estimation, bad. Like several other species of salmon, they are very regular in the periodical arrivals at the mouths of the rivers. In 1856 they arrived in the vicinity of Fort Steilacoom on the 3d of October, and by the 7th were in such vast numbers that a small boy with a pole armed with a gaff-hook could readily take one or two hundred pounds weight in an hour."

The Indians say that, although this species enters the rivers later than the *S. scouleri*, it returns earlier, staying a shorter time away from the sea. They say, also, that most of the individuals return to the sea after spawning, many more comparatively than do of the *S. scouleri*. They say that all individuals of the *S. proteus* die. The dog-salmon is preferred by the Indians for drying, as it has but little fat. It is found sparingly in the Straits of Fuca and the entrance of Puget Sound as early as August 10.

7. SALMO SALAR, Linnæus.

COMMON SALMON OF EUROPE.

We are by no means satisfied that this European species exists on the American coast, although Dr. Storer, De Kay and others have so written. Herbert, quoting Mr. Perley, says that the *Salmo trutta*, Flem., of Europe, is also found, and it has been stated that the *S. hamatus*, Cuv., occurs. Most probably these species are, if ever found, only met with as accidental individuals; and those fish taken after cursory examination to be identical with the European are really of distinct species, analogous to or the counterparts of their relatives on the other side.

The description of *Salmo salar*, contained in Storer's synopsis, is so meager that it is useless for purposes of identification. Those of other authors are exceedingly contradictory. Jenyns, in his "Manual of British Vertebrate Animals," gives the following character as pertaining to the species: "Form, oval; moderately elongated, with the head and back in nearly the same line; the greatest depth a little before the dorsal; contained about five times and a half in the entire length, increasing, however, with age; thickness, half the depth, head small, about one-sixth of the entire length; snout rather sharp; jaws in young fish nearly equal, but in old males the lower one longest and curving upward in a hook. A row of sharp teeth along both sides of each jaw as well as on the palatines; but those on the vomer confined to its anterior extremity, and in some specimens rather obsolete.

"The only specimen in the Smithsonian collection, obtained from the American coast, which closely approaches the *S. salar* of Europe, is the head of a salmon supposed to have been brought from Maine, having been purchased in the Washington market. In certain respects the fish undoubtedly approaches the European species, if we may be allowed to judge by the head alone. Compared to the specimen sent from the Swedish Academy, and labelled *S. salar*, (of the correctness of which name we have, however, strong doubts,) we find the head comparatively much wider between the eyes, and posteriorly, in the Maine specimen. The taper of the snout and lower jaw is more rapid; their extremities sharper; teeth more irregular in size, and the angle of the mouth but little behind a line drawn vertically from midway between the eye and nostril; whereas in the European specimen the angle, when the jaw is moderately drawn down, is found just beneath the pupil. The shape of the pre-opercula also differ; that of the Maine fish having its posterior border nearly vertical, and not, as in the European specimen, arching almost parallel with the semicircular curve of the operculum.

"In addition, the vomer of the American fish has no teeth upon its shaft, and but two on its anterior extremity, in this respect agreeing with Jenyn's description of *S. salar*, but differing from the Swedish specimens, which have two rows of teeth upon the shaft of that bone."

The Swedish specimen (102, adult) shows scattered dark spots along the sides, and numerous small, round dark spots on the opercules and pre-opercula. Tail unspotted.

8. SALMO QUINNAT, Richardson.

QUINNAT.

SYN.—*Salmo quinnat*, RICH. F. B. A. iii, 1836, p. 219; DE KAY, N. Y. Fauna, iv, 1842, p. 242; STORER, Synopsis, 1846, p. 196; HERBERT, Supplement to Frank Forrester's Fish and Fishing, &c., 1850, p. 31; GRD. in Proc. A. N. Sc. Phil., viii, 1856, p. 217; IBID. Pacific R. R. Reports, vol. vi; IBID. Gen. Rep. Fishes, p. 306; SUCKLEY, P. R. R. Rept., vol. xii, Part 2, p. 321; IBID. N. H. Wash. Terr. &c., p. 321.

Common Salmon, Lewis and Clarke.

Figures.—A young fish called by this name, and probably belonging to the species, has been figured under Dr. Girard's supervision, and appears in the volume on the fishes collected by the United States Pacific Railroad surveying parties, Plate lxvii.

SP. CH.—*Adult.*—Head pointed and large, forming about a fourth of the length from the snout to the end of the scales on the caudal. Dorsal outline regularly arched. Caudal deeply cut out, (in the dried specimen forked,) snout cartilaginous, as in *S. salar*. Chin pointed, a triangular bare projection extending beyond the teeth.

"General tint of the back bluish gray, changing after a few hours' removal from the water, into mountain green; sides ash-gray, with silvery luster; belly white; back above the lateral line studded with irregular rhomboidal or star-like black spots, some of them ocellated. Dorsal fin and gill-cover slightly reddish; tips of the anal and pectorals blackish gray; the dorsal and caudal thickly studded with round and rhomboidal spots; back of the head sparingly marked with the same. Whole body below the lateral line, with the under fins, destitute of spots." (Gairdner in Rich., F. B. A. Fishes, 220.) Scales large. Branchiostegal rays varying from 16 to 20.

Young ?—"Body fusiform in profile; compressed; head forming about the fifth of the total length; maxillary bone curved, extending beyond the orbit; anterior margin of the dorsal equi-distant between the extremity of the snout and the insertion of the caudal; dorsal region olivaceous, studded with irregular black spots; dorsal and caudal fins similarly spotted. Region beneath the lateral line unicolor, silvery along the middle of the flanks, and yellowish on the belly; inferior fins unicolor; head above blackish-gray; sides bluish-gray."—Girard.

Based on a specimen, No. 939, Smithsonian collection.

HAB.—Pacific coast of North America, from San Francisco northward; entering the larger rivers in great numbers annually.

This being the most important salmon, both in excellence and numbers, found in the western waters, I have taken the liberty of reproducing a portion of the remarks on the species which were embodied in the report

on this family furnished by the writer for the twelfth volume Pacific Railroad Reports:

In shape, and in many other particulars, this fish agrees with the description given in Pallas, Zoog. Ross. Asiat. of the *S. orientalis*, and, as quoted by Brevoort in notes on some figures of Japanese fish, like it, reaches a weight of sixty pounds; ascending the larger rivers only in the months of April, May, and June; in having fleshy lips, and in gastronomic excellence. It also has a large pointed head, with very similar jaws. It differs from Mr. Brevoort's figure in having the tail much more deeply cut out—almost forked—and in having spots on the back and head. It also but seldom attains the large size given above, the average being usually about twenty-five pounds. Valenciennes says that the *S. orientalis* has numerous crescent-shaped spots above the lateral line. This remark is based on a drawing, taken by Mertens, of a female. (See Brevoort's work above quoted, p. 23.) The *S. quinnat*, according to Gairdner, has the spots differently shaped.

In a memorandum furnished me by George Gibbs, esq., he says that in a visit to Chinook, near the mouth of the Columbia, he saw "the true spring salmon of the Columbia. Speckled on back, fins, and tail, with half-moon spots. Tail in large specimens not always spotted. Tail forked." The *S. quinnat* is designated by Lewis and Clarke as the "common salmon" of the Columbia. It was first scientifically described by Sir John Richardson from specimens and notes obtained from Dr. Gairdner, who was then (about the year 1835) living at the trading-post of the honorable Hudson Bay Company, situated on the right bank of the Columbia, nearly opposite the mouth of the Willamette River, about one hundred miles from the ocean, then and still known as Fort Vancouver. While stationed as surgeon at that important point, Dr. Gairdner, in a most praiseworthy manner, busied himself actively in studying the natural history of the region; and in connection with the labors of Tolmie, Townsend, Nuttall, and Douglass in the field, and of Richardson, Hooker, Audubon, and Bachman in the study, presented to the public almost all that was known to naturalists of that remote portion of the world up to the period when the late scientific explorations were undertaken under the auspices of our Government.

This salmon is, perhaps, the finest of all that enter the rivers and inlets of our Pacific possessions. The adults are readily recognized by the settlers from their great size and their large deeply-forked tails. When fresh from the sea they are in superb condition for the table, equal, in our estimation, to the best English or Scotch salmon.

The color of the flesh is of the richest "salmon-red." The general external appearance of the fish presents very bright silvery reflections. They first arrive in the Columbia River during the month of April—the periodical advents usually varying but a few days.

Lewis and Clarke speak of their first arrival at the Skilloot village, below the site of Fort Vancouver, on the 18th of April, 1806, and at the Dalles (two hundred miles above the mouth of the Columbia) in the year

1807, on the 10th of April. Major G. I. Rains, United States Army, noticed them at the latter place in 1854, on the 28th of April, and I myself saw the first of the season in 1855, April 11. George Gibbs, esq., in mss. notes informs me that in 1853 the same species were "in season" at the mouth of the Columbia on the 20th of April.

The *quinnat*, in an economical point of view, is by far the most valuable salmon of any species found in Oregon. The extreme richness and delicacy of its flesh cause it to be much preferred for salting, and were it not for the hitherto high prices of labor, barrels, and salt, it would have, ere this, been found a staple article of export from the Columbia. In numbers they seem to be inexhaustible, and are readily taken in nets and otherwise. During the "season" they are so abundantly taken at the rapids near Dalles that, notwithstanding the high rates at which most articles of domestic consumption are sold, I have frequently purchased noble specimens of this fish, weighing twenty pounds or more, each, for the small price of a quarter of a dollar. The Indians on the Columbia take immense numbers, eating what they need while fresh, and drying thousands for winter consumption or for trade. The principal method of capture employed at the Dalles is by "scooping" at random in the rapid water as it passes a projecting rock along the banks of the stream. The salmon, keeping close to the shore, in order to avoid the force of the current, take advantage of "shore eddies" in their ascent. The Indian selects a proper location, generally by a projecting rock, upon which he builds a platform, and with a "scoop-net" about four feet in diameter, attached to a long pole, rapidly sweeps the water below. The net passing down with the current, and immersed four or five feet below the surface, is alternately dipped and drawn up, again to be plunged in the boiling waters above. During the height of the season it is not uncommon for a single man thus to take twenty or thirty fish in an hour. The time chosen is usually during the long twilight of the evening or early morning. Whether this is because the fish do not "run" during the the bright hours of the day, or because they, seeing better, avoid the net, I am in doubt.

For subsequent consumption the salmon are split open and the entrails and back-bone taken out; they are then hung up in the lodges to dry in the smoke. When perfectly dry they are packed in bundles and kept in baskets or mats, and in some places, as along the river from Walla-Walla to Fort Colville, large stores are placed on platforms raised on poles some twelve or fifteen feet from the ground. This is to protect them from the ravages of the wolves. To guard against rain and the plundering propensities of crows, magpies, and ravens, they are covered with mats or strips of bark, and occasionally with rough-hewn boards. No salt is used by the savages in preparing the fish; nevertheless, the food thus preserved keeps in good order for several years.

Four undoubted specimens of the *S. quinnat* * are in the Smithsonian

* A much fuller collection in the present day.

collection, two of which were sent by Mr. James Wayne, of Astoria, Oregon. A fifth specimen, obtained by the writer from Puget Sound, is the skin of a young fish, labeled by Dr. Girard *S. argyreus*. Although immature, it resembles more the present species than any other I have been able to compare it with. In an appendix to the private edition of the report above quoted (published under the title of Natural History of Washington Territory) the following additional information concerning this species was included:

"The *Salmo quinnat*, Rich., (see page 321,) we have ascertained by careful examination to be the principal species brought to the San Francisco markets. It was found abundant there during the months of January and February, and could easily be recognized by its large head and pointed jaws, and by the number of its branchial rays, which are usually over fifteen in number. The tail is large, and well cut out, and the lower fins unspotted. We heard of two specimens which had been brought to the market that weighed sixty-four and a half pounds each. These were the largest that we have known of in that locality, but fish of seventy pounds, it is said, have been caught farther north. This must be about the maximum weight to which it ever attains.

"The *quinnat salmon* is obtained for the San Francisco market by fishermen in the Sacramento River, who take them with gill-nets, much in the same way as shad are caught in the Hudson.

"The fishmongers to whom the question was put, whether any peculiarities in external appearance serve to distinguish the sexes, answered that they knew of none. The same species of salmon was found, about the 1st of December, abundant in the bay at Port Townsend, and at Port Gamble, Puget Sound. The Indians took them in moderate quantities, by trolling in the manner described on page 329. These salmon were not running up the rivers, not yet impelled by instinct so to do, as their ova thus early in the season were but very slightly developed.

"In the San Francisco market we also noticed a small salmon, more spotted, with smaller head and more rounded jaws than the *quinnat*—in fact, much more nearly resembling the *S. gairdneri* or the *S. truncatus*. This kind is called by the dealers salmon-trout. It does not appear to attain a very large size, rarely exceeding 28 inches, and is for its real or supposed excellence sold for a much greater price than the Quinnat."

Mr. George Gibbs states that the Skagit Indians believe that the *yomutsh salmon* die after spawning. The largest he saw weighed forty pounds, and were about three feet in length. They become worn out by July or August. The Simiahmoo Indians, speaking another dialect, say that the *kwitshia* (*S. quinnat?*) alone bite at the hook. We have seen many of the *S. quinnat* taken with hook and line at Port Townsend.

Mr. Gibbs in his notes describes the manner the Lummi Indians take salmon in salt water by a net about 15 feet square, dipped several feet under water at the front end, but kept stretched between two canoes,

the hind part of the net being lifted a little above the surface. The canoes are propelled gently along, and when salmon are felt the net is raised like a dip-net, and thus the fish are captured. They occasionally in this way will capture fifty salmon at one "lift."

9. SALMO CONFLUENTUS, Suckley.

TOWALT SALMON.

Typical specimen in Smithsonian collection Fishes, No. 1135.

SYN.—*Salmo confluentus*, SUCKLEY, Ann. N. Y. Lyc., December, 1858; IBID, P. R. R. Rep., vol. xii., pt. 2, 1839.
Towalt of the Nisquallies.

SP. CH.—*Male.*—Form, stout; dorsal outline rising to a point just anterior to dorsal fin, then rapidly tapering to tail; dorsal, adipose, and caudal fins profusely spotted; caudal broad and moderately lunated; adipose opposite anal, and much elongated; spots along the back and sides, generally linear, or V-shaped; others irregular, (but few round,) covering from two to five scales; the most common cover three scales, and are about half an inch in length; fins on under parts unspotted, as also all parts beneath the lateral line. A triangular bare projection of the chin, anterior to the front teeth, as in the *S. quinnat*, but smaller; scales scarcely as large as those of *S. truncatus*. Teeth of irregular size, and not so closely disposed on the arms of the jaws and labials as in *S. gairdneri;* middle of dorsal fin nearly opposite a point at the middle of the total length. Differs from *S. quinnat* in having the tail but moderately lunated at the extremity, that of the latter being so deeply cut out as to be almost forked; in the number, shape, and size of its spots, and in its smaller head.

Young? (Characters drawn from a young *tsah-kwai*, sent by Dr. Kennerly from Chiloweyuk Lake, No. 203 in the doctor's collection.) Head contained $5\frac{1}{2}$ times in the total length. Tail handsomely forked. Dorsal, adipose, and caudal spotted with oval black spots. Head spotted with round spots of the same, each about $1\frac{1}{2}$ lines in diameter. Br. 16: P. 17: D. 15: V. 11: A. 16: C. 20: rows of scales just in front of dorsal, 31 above lateral line; 42 below; 145 upon it.

HAB.—Northwest coast of America, entering the rivers for spawning purposes during the spring, and continuing throughout the summer.

A very large salmon, known to the Indians of Puget Sound as the *towalt* or *to-oh-odlt*, is caught in Black River, a fork of the Dwamish. It is said that this species is distinct from the *satsup*, (which we take to be the *quinnat*,) but it is identical with the *tsah-kwai* of Fraser River.

Mr. George Gibbs, while on Fraser River, speaks of the salmon known to the natives there as the *tsah-kwai*. He says: "A few enter Fraser river as early as March, but they are so few that they are not caught at the fisheries before April. Mr. Gibbs mentions obtaining in the Haro Straits, on the 12th of March, 1859, one of these salmon. "Belly, silvery-white; back, dark olive-green on the ridge; sides, lighter and with

light bronze reflections to within an inch of the lateral line, with black linear spots on the same; tail and dorsal fin, speckled; head small and pointed; ventral fins commence nearly as far back as the dorsal ends; scales very small and bright. At this date they are still scarce."

A *tsah-kwai* obtained by Dr. Kennerly at L. Chiloweyuk, September 8, 1858, had, according to the doctor's notes, a length of 3 feet, 10 inches, (nearly 4 feet,) and an abdominal circumference of 1 foot, 10 inches. Black spots on the tail as large as a buck-shot; those of the dorsal fin oblong. General color, silvery-grey with metallic lustre. Lateral line very distinct. Sides above the lateral line with irregular black spots. Snout projects a little when the mouth is closed. Head 8 inches long.

This species was in good condition and abundant at Chiloweyuk at date. He also adds: "This species is the largest found in these waters. Its meat is quite white and not so much esteemed as the *suk-keh*, which has red meat." In speaking of a young specimen he says: "The spots are quite distinct, perhaps of larger size in proportion than those of the adult."

10. SALMO AURORA, Girard.

SYN.—*Fario aurora*, GRD. Proc. Acad. Nat. Sc., Philad., viii, 1856, p 218; IBID. P. R. R. Rep., vol. x, 1858, p. 308.
Salmo aurora, GRD. Suckley, P. R. R. Rep, vol. xii., part 2, p. 343; IBID. Nat. Hist. Washington Territory, p. 343, pl. 6 8.
? ? *Red-char*, Lewis and Clark.

SP. CH.—Body fusiform, compressed; head forming the fourth of the total length, caudal fin excluded; upper jaw longest. Maxillary gently undulating, its posterior extremity extending to a vertical line passing considerably behind the entire orbit. Anterior margin of dorsal fin equidistant between the tip of the snout and the base of the caudal. Ground color, greyish-silvery above; sides and belly, yellowish-orange; dorsal fin spotted.—Girard.

The two specimens from Astoria still remain in the Smithsonian collection. No others have been received since their arrival in 1854. Dr. Girard's description (based upon the characters of what appear to be young of immature fish) gives very uncertain data for the identification of adults of the species. The typical specimens are numbered 583 on the museum register.

Collectors near the mouth of the Columbia would do well to preserve for study and comparison several small (healthy) red salmon, if they can be obtained.

11. SALMO ARGYREUS, Girard.

SYN.—*Salmo argyreus*, GRD. Pacific R. R. Rep., vol. x, 1858, p. 312, pl. 52; SUCKLEY, P. R. R. Rep., p. 326, and Nat. Hist. Wash. Terr., p. 326.
Fario argyreus, GRD., Proc. A. N. Sc., Phil, viii, 1856, 218; IBID. Pacific R. R. Rep., vol. vi, part iv, p. 32.

As the description of this species given by Dr. Girard seems based on the characters of two young, partially grown fish, the specific characters

thus deduced are probably much unlike those of the adult in good condition.

Sp. Ch.—"Body very much depressed, rather deep upon its middle region, and quite tapering posteriorly. Head moderate, constituting the fifth of the entire length. Jaws equal. Maxillary slightly curved; its free extremity extending to a vertical line drawn posteriorly to the orbit. Anterior margin of dorsal fin nearer the extremity of the snout than the insertion of the caudal fin. Bluish-grey above; silvery along the middle of the flanks; yellowish beneath."—Girard.

Three specimens are in the Smithsonian collection, labeled by Dr. Girard, as belonging to this species. From two of these, also, he based his description, and had the drawing of Plate lxx, Gen. Rep. Fishes, P. R. R. Rept., made. They are alcoholic specimens, and are numbered on the museum register 579, 580.

The least examination shows that both were very young fish—so young as to render it impossible to decide with certainty to what species they really belong. In many characters they resemble the *S. quinnat*, and particularly so in having fully fifteen branchiostegal rays.

12. SALMO PAUCIDENS, Richardson.

WEAK-TOOTHED SALMON.

Syn.—*Salmo paucidens*, Rich. F. B. A. iii, p. 222;—Herbert, Sup. to Fish and Fishing, &c. 1850, p. 36;—Suckley, Nat. Hist. Wash Terr. and P. R. R. Reports, vol. xii, p. 325, 1859–'60.

Dr. Girard's species, the *S. aurora*, has the back well arched. This may be owing to youth. Were it not for this circumstance the exceedingly small, weak teeth of the specimens labeled by the doctor as *S. aurora*, (and from which he based his description of the species) would induce us to consider the latter name only as a synonym. The young of all the species of salmon known to the writer have forked tails, and it is, therefore not until the fish have reached adult age that this character can be relied on as specific.

The salmon in Dr. Kennerly's collection from Frazer River, labelled the *suk-kégh*, and described by us in "Notices of Several New Species of Salmonidæ, &c., New York, June, 1861," as the *Salmo richardi*, comes nearer to this species than any that we have received from the Pacific coast, even including the *S. aurora*. More specimens from the Columbia will settle the question.

For discussion of certain points in connection with *S. paucidens*, we refer to the works last quoted in the synonymy above.

13. SALMO TSUPPITCH, Richardson.

WHITE SALMON.

Syn.—*Salmo tsuppitch*, Rich. F. B. A. Fishes, 1836, p. 224;—De Kay, N. Y. Fauna, iv, 1842;—Storer, Synop. 1846, p. 197;—Herbert, Supplem. to Fish

and Fishing, 1850, p. 39;—SUCKLEY, Nat. Hist. of Wash. Territory, 1859. (not *Fario tsuppitch*;—GRD. Pr. A. N. Sc. Phil., viii, 1856, p. 218;—IBID., Gen. Rep. Fishes P. R. R. Rep., 1858, vol, x, p. 300.)

? *White Salmon,* Settlers on the Columbia.

? *Silvery-white Salmon-trout,* Lewis and Clarke.

Figures.—The plate (LXIX, figs. 1–4) in the P. R. R. Reports, represents the *Salmo gibbsii,* and not this species.—(See remarks on *S. gibbsii.*)

SP. CH.—Convexity of dorsal outline rising gradually to origin of first dorsal, declining from thence to the tail. *Caudal forked.* Head small, *exactly conical,* terminating in a *pointed snout.* Commissure of mouth very slightly oblique. Back of body and head studded with oval and circular spots; *sides and fins, including the caudal, destitute of spots.* Teeth minute and sharp; a single row on each palate bone, a few on the anterior end of the vomer, and a double row on the tongue. [The foregoing description is deduced from Dr. Gairdner's notes in Rich. F. B. A., p. 224.] The portions italicized in the above summary of specific characters are those differing strongly from a correct description of the fish taken by Dr. Girard for this species, and described by me as the *S. gibbsii.*

The description, &c., above quoted is copied bodily from the Report on the Salmonidæ, by the present writer, contained in part 2, twelfth volume Pacific Railroad Reports, and duplicated in the work entitled Natural History of Washington Territory. Since then no additional information has been obtained concerning the fish, although careful inquiries have been made.

14. SALMO CLARKII. Richardson.

CLARK'S SALMON.

SYN.—*Salmo clarkii,* RICH. F. B. A. iii, 1836, p. 224;—STORER, Synop. 1846, p. 197;—HERBERT, Fish and Fishing of the U. S. Suppl., 1850, p. 40;—SUCKLEY, P. R. R. Report, vol. xii, p. 344, 1859;—IBID., Nat. Hist. Wash. Territory, 1860. (not *Salmo clarkii,* GRD.)

SP. CH.—(Drawn from Richardson's description and Dr. Gairdner's notes.) Dorsal profile nearly straight. Ventrals opposite to the middle of first dorsal. Fissure of mouth oblique. Extremity of caudal nearly even. Both jaws armed with strong hooked teeth, a single row on each palate bone, and a double row on the anterior half of the vomer and on the tongue. The teeth are long, slender, and acute. Lingual teeth longest and most curved, An oblong plate on the isthmus which unites the lower ends of the branchial arches rough, with very minute teeth. Sixty-six vertebræ in the spinal column.

From the colors given by Dr. Gairdner we infer that they were noted from partially exhausted individuals of some species of anadromous salmon. He says: "Back generally brownish purple—red, passing on the sides into ash-grey, and into reddish white on the belly. Large patches of dark purplish-red on the back, dorsal and base of the caudal

ash-gray; end of caudal pansy-purple. Back, dorsal, and caudal studded with small semi-lunar spots. A large patch of arterial-red on the operculum and margin of pre-operculum. Pectorals, ventrals, and anal, grayish-white, tinged with rose red."

Rays.—"Br. 11; P. 12: V. 8: A. 13: D. 11–0." The original specimens were obtained by Dr. Gairdner at the Cathlapootl River, a small tributary to the Columbia. None have been obtained during the recent explorations, although it is by no means improbable that some one of the species lately described from healthy-run individuals may really be identical with this fish. For further remarks and suggestions concerning *S. clarkii*, see "Nat. Hist. Washington Territory," or Pacific R. R. Reports, vol. 12.

15. SALMO IMMACULATUS, Storer.

THE UNSPOTTED SALMON.

SYN.—*Salmo immaculatus*, H. R. STORER. Bost. Journ. Nat. Hist., vi, pp. 264–269.

SP. CH.—(Drawn from Storer's original description.) Length of head about one-sixth that of the body; its depth two-thirds of its length. Jaws with numerous sharp incurved teeth. Eyes laterally elongated, their diameter one-third the distance between them. Opercles rounded posteriorly; below, naked and marked with concentric striæ. Pre-opercle larger than in *S. fontinalis.*

Scales larger than those of *S. fontinalis.* Lateral line commences back of superior angle of the operculum, and assuming the curve of the body is lost at the commencement of the caudal rays. The first dorsal commences just anterior to median line, and is nearly quadrangular.

Fins.—Adipose at a distance back of the first dorsal little less than one-half the length of the fish. Pectorals just beneath posterior angle of the operculum; their length three-fifths that of the head. Ventrals just beneath posterior portion of first dorsal. The plates, at their base, very large; anal about the length of the head behind the ventrals, terminating directly beneath the adipose fin. Caudal deeply forked, its length equal to greater depth of body.

Colors.—Silvery on sides and abdomen; darker on back. No spots.

DIAGNOSIS.—The diagnosis between this species, if it should really prove distinct, would be by the following: Its silvery color; absence of spots; great length of head compared to the body, the strongly forked tail and its great length. "D. 9: P. 13: V. 9: A. 11: C. 30."

The specimen described by Dr. Storer appeared to be unique. Its length was thirteen and a half inches, and from that circumstance, and from the deeply-forked tail, I am strongly inclined to consider it as that of a young fish, probably belonging to some species already known—perhaps *S. trutta*. The naming of salmonidæ, and the description of new species, based upon the characters of young, partially developed fish, cannot be too strongly reprobated. There is already too much confusion in the synonymy of the various kinds; and if the practice of

describing and naming new species from the characters of unidentified, immature individuals is not stopped, the study of the relations of the species will become so complicated that useful classification will be next to impossible, and the principal object and usefulness of scientific arrangement, such as simplifies the study of natural history in other branches, will be greatly impaired. Examples of description based on young fish are *Salmo newberrii*, Grd., and *Salmo* (*Fario*) *argyreus* Grd. Errors of this kind might easily be avoided by a little care in labeling by the collector in the field. These remarks are meant generally, and not to reflect upon individuals.

Dr. Storer adds to his description the following statement: "But a single specimen of this beautiful fish was taken, and that by a gill-net stretched across the mouth of a brook flowing into Red Bay, Labrador."

16. SALMO GAIRDNERI, Richardson.

GAIRDNER'S SALMON.

SYN.—*Salmo gairdneri*, RICH., Fauna B. A., Fishes, 1836, p. 221;—DE KAY, N. Y. Fauna, iv, 1842, p. 243;—STORER, Synop., 1846, p. 196;—HERBERT, Suppl. to Fish and Fishing of the United States, 1850, p. 34;—(not *Fario gairdneri*, GRD., Pr. A. N. Sc., Phil., viii, 1856, p. 219;—IBID. Pacific R. R. Reports, vol. vii; et Gen. Rep. Fishes, p. 313, Plate lxxi, fig. 1–4);—SUCKLEY, P. R. R. Rep., vol. 12, p. 331;—IBID. Nat. Hist. Wash. Terr., p. 331. *Quannich or Kwnannich* Chinook, (not jargon.)

SP. CH.—[Based on data given by Richardson, and on the examination of two dried skins in the Smithsonian collection.] Profile of dorsal outline nearly straight; tail terminating in a slightly semilunar outline. Ventrals correspond to commencement of dorsal, and adipose to end of anal. Jaws fully armed with strong hooked teeth, except a small space in center of upper jaw. Vomer armed with a double row for two-thirds of its anterior portion. Back of head and body, bluish gray; sides, ash gray; belly, white; caudal, spotted with oval dark spots; snout, rounded; head, short and comparatively broad; under fins, light-colored.

HABITAT.—Pacific Ocean, northwest coast of America. Enters and ascends the Columbia in the spring.

DIAGNOSIS.—From *S. quinnat* by its round muzzle and chin, and when adult by lacking the forked tail. From *S. truncatus* by its broad head at the base; its round "snub" snout. [For further marks of difference see those species.] It resembles the *S. truncatus* in its short head, small teeth, truncate tail, and large scales. In the specimen examined the operculum differs considerably in shape from that of the male *S. quinnat*.

Gairdner's salmon enters the Columbia in the spring in company with the *S. quinnat*. It is a fine silvery fish, and equal in flavor and delicacy to the latter, but much smaller in size; the average, according to Dr. Gairdner, being about six or seven pounds.

Two skins are in the Smithsonian collection, sent from Astoria by Mr. James Wayne.

17. SALMO TRUNCATUS, Suckley.

SHORT-TAILED SALMON; SQUARE-TAILED SALMON.

SYN.—*Salmo truncatus*, SUCKLEY. Ann. N. Y. Lyc., Dec., 1858.—IBID. Pacific R. R. Reports, vol. xii, p. 327, 1859.

Klit-shim of the Klallams.

Typical specimen, No. 1134, Smithsonian collection.

SP. CH.—[Based upon the skins in the Smithsonian collection.] Body, fusiform; dorsal outline but slightly arched; anterior margin of dorsal fin much anterior to a point equidistant between the nose and the insertion of the tail; head very small; jaws fully provided with small teeth; tail small, its free margin, when extended, being almost straight, having a very faint tendency to lunation; scales large. Colors of the fresh run fish: Back of head, back, dorsal and caudal fins bright blue, spotted on the head with roundish, on the fins with oval spots of black; the blue of the back is silvery, that of the head and fins darker; lower parts silvery white, this color extending about an inch above the lateral line, and merging itself irregularly into the color of the back; no spots below the lateral line, which is faint and of a bluish dusky color; lower fins pale and unspotted, their tips somewhat darkish. Abdominal cavity comparatively small; fish weighty for its size; usually two rows of teeth along the body of the vomer.

The male has a slightly larger head than the female; the teeth are also stronger; and between the front teeth opposite the intermaxillary a notch exists for the reception of the more pointed chin. It probably never becomes "hooked-billed."

DIAGNOSIS.—From *S. quinnat* can be distinguished by its more rounded snout and chin; by lacking the triangular bare space in front of the maxillary symphysis anterior to the teeth; by its short head; even, spotted tail; and by its large scales, which are double the size of those of the *quinnat*. From *S. gairdneri*, Rich. Snout and angle of jaws sharper; head much narrower at the base and more tapering; scales slightly larger.

The species are however nearly allied. [For remarks in detail concerning the differences and affinities between this and other salmon, see Pacific Railroad Reports, vol. xii, part 2, page 328.]

HAB.—Anadromous; Puget Sound; ? Columbia River.

Since the preparation of the twelfth volume of the Pacific Railroad Reports, Dr. Kennerly obtained and forwarded some additional material, (skins 2097, 1119.) No. 2097 was obtained during the winter of 1859 at Fraser River; the other in the Straits of Fuca, in August. We have, therefore, been able more satisfactorily to determine the distinctions between this species and the *S. gairdneri*. Mr. Gibbs now seems to think this fish is not identical with the *skwowl* of the Nisquallies.

The measurement of the head of the typical specimen mentioned in the last works quoted in the synonymy was taken from the snout over the

vertex along the median line, and not from snout to farthest point on edge of operculum. It was this measurement of the head which was one-thirteenth of the fish's total length.

The following is extracted from the report on the Salmonidæ in the Pacific Railroad Report, vol. xii:

While residing at Puget Sound I collected the following information from the Indians respecting the salmon known to the Nisquallies as the *skwowl*, which I consider identical with the *klutchin* of the Klallams, a specimen of which has served as the typical example of the present species. This fine salmon is second to none in beauty, size, or excellence. It arrives in the bays and estuaries of Puget Sound about the middle of autumn, and toward the 1st of December commences to run up the larger rivers emptying into the sound. Their ascent of these streams continues through December and January. This arrival of the species in fresh water is not as simultaneous, neither do they arrive in such great numbers at any one time or in schools, as is the case with the *skowitz*, and several other species, but the "run" being somewhat more "drawn out" affords a steady, moderate supply to the Indians during its continuance. In the fall and winter large numbers are taken by the Indians from the salt water by trolling with hook and line in the bays and coves of Puget Sound. The bait used is generally a small kind of herring, a little larger than the common sardine of commerce. After entering the rivers it is taken by the Indians in nets, traps, baskets, and also by spearing. Its flesh when cooked is of a beautiful salmon-red, and, as a table delicacy, when fat, as it generally is when "fresh run," ranks equally with that of the *S. salar*, the *satsup*, or the *quinnat*. The Cowlitz River, (a branch of the Columbia,) situated not more than sixty miles from the head of Puget Sound, has salmon of various species entering it at regular periods annually. Indians of intelligence have told me that the species under consideration is the only kind common to both these waters. How far we can place reliance on their statements is difficult to determine.

The distinguishing characters which strike the eye at a glance are its short and small head, the small weak teeth in the jaws, and the shape of its tail, which is truncated, not forked. Mr. George Gibbs says that the *S. truncatus* (*klitshin* or *klut-chin*) has the most solid meat of all the salmon, and has a very small abdominal cavity. It keeps its depth to the insertion of the tail, and weighs more in proportion than any other. Body covered with small black, roundish spots; back, dark olive; sides, gray; belly, white—gray behind; nose straight. A specimen obtained by him, 29 inches in length, had a girth in front of dorsal fin of 17 inches; girth at insertion of caudal, 7 inches. Length of head, 5 inches; nose to dorsal fin, 13.75 inches; breadth of tail, (at extremities of lobes,) 6 inches. Scales small; weight, 9.75 pounds; male. Whether this be the *skwowl* or not, the fact that *skwowl* enters the rivers in mid-winter and is gone or exhausted when the *S. quinnat* arrives, is of value, and will afford a clue to the collector.

18. SALMO RICHARDI, Suckley.

SUK-KEGH SALMON; RICHARD'S SALMON.

SYN.—*Salmo richardii*, SUCKLEY, Notices New Species N. Am. Salmon. N. Y., June, 1861.
? *S. paucidens*, RICH., F. B. A.

SP. CH.—[Based on a skin in alcohol, No. 2005, Smithsonian Cat.; Fishes.] Dorsal outline moderately convex, its point of greatest height being at the insertion of anterior ray of dorsal—the arch from the snout to the caudal insertion being very uniform.

Female.—Head conical; jaws apparently equal—the thick, fleshy tip on the point of the lower jaw of the fresh-run fish aiding much to give this appearance. Maxillary extends back to a point immediately below the posterior of margin of orbit. Teeth extremely small, and but few. Tail deeply lunated—almost forked. Tail and other fins unspotted. Does not often attain a greater weight than fifteen pounds—the average being scarcely more than eight. Br. rays, usually 14.

HAB.—Northwest Pacific coast. Enters Fraser and Skagit Rivers. The species is named in honor of Mr. J. H. Richard, the clever artist who has so handsomely and correctly drawn the ichthyological illustrations of the Pacific Railroad Reports.

DIAGNOSIS.—The forked or deeply lunated tail will serve to distinguish the species from those not possessing that character. From the *quinnat* it differs in lacking the strong teeth and pointed, triangular, smooth, projecting chin which extends in front of the teeth of the latter. The unspotted tail and fins assist in the diagnosis. Concerning its identity with *S. paucidens*, see text beyond. The "lip" in front of the teeth on the lower jaw is not triangular, but is rather thick, extending some distance in front of the teeth, and in this respect approaching to the *S. quinnat.*

This salmon runs up Fraser River in great numbers, where it is the principal summer salmon. In the Skagit it occasionally is found, and is there considered a great rarity by the natives, who call it *oheh-itl.* This fish in many respects agrees with Richardson's description of the *S. paucidens.* But as that is so meager and may apply to the young of so many different kinds, I have been guided by the known difference of time in their arrival from the sea. Dr. Gairdner says that the weak-toothed salmon enters the Columbia in company with the *S. quinnat*, (in April and May,) whereas the *suk-kegh* does not run up Fraser River until later.

"The procuring of specimens from the Columbia of the salmon known to the Indians of the lower river as the *kwe-achts*, would settle this question.

"The *suk-kegh* is the best summer salmon of Fraser River, being in prime condition in the rivers during August and the early part of September. When they enter Lake Chiloweyuck they almost immediately die, owing,

as the Indians believe, to something peculiar in the water.—(Kennerly, in MSS.) Dr. Kennerly in a note made on the 13th of September, 1859, says that he had that day "observed many dead salmon floating on the lake."

Mr. Gibbs found the species in full run August 1, 1857, in the salt water on the west side of Lummi Island.

II. Spotted with red, feeding freely in fresh water.

19. SALMO CAMPBELLI, Suckley.

PACIFIC RED-SPOTTED SALMON-TROUT; CHEWAGH.

SYN.—*Salmo spectabilis*, GRD. Proc. A. Nat. Sc. Ph. viii, 1856, p. 218;—IBID. Pacific R. R. Rep., vol. xii, p. 307;—SUCKLEY, Rept. on the Salmonidæ, P. R. R. Reports, vol. xii, and Nat. Hist. Wash. Terri., p. 342.

Salmo campbelli, SUCKLEY. Notices of certain New Species of N. A. Salmon, June, 1861.

SP. CH.—A slender fish for the genus. Head, measured from snout to distal edge of operculum, contained about four and three-quarter times in the total length; measured from snout to nape, it is contained seven and a half times. When the pectorals are smoothed backward against the belly the point of greatest girth is along a line drawn vertically near their ends; from whence to the snout there is a regular curve, but posteriorly the line of the back is quite straight, the body being somewhat compressed latterly and tapering. Scales much smaller than in individuals of *S. iridea*, Gibbons, of the same size. They are very delicate and easily detached. Caudal, forked. Back and sides, low down, are covered with spots (about two lines in diameter in a fish one foot long;) those near the lateral line being of a beautiful rose-color; those above and below, cream-colored or white. Tail forked. A small clump of teeth on anterior extremity of the vomer as in the chars, or *Salvelini* of Nilsson.

DIAGNOSIS.—Known from all the Pacific trouts by the red spots on the sides, and whitish ones on the back.

In 1856 Dr. Girard described a trout sent by me from the Dalles on the Columbia River. The specimen was very much broken, and the description vague. I have, however, succeeded in identifying other specimens sent by Dr. Kennerly from Puget Sound, by comparing these with the remains of the original typical specimen.

In two of these fish in the Smithsonian collection there are two teeth on the head of the vomer, and on each side, and two on the shaft. One specimen had 42 scales above the lateral line to middle of the back; 40 below the lateral line, and 156 upon it.

Rays.—Br.? D. 12: P. 17: V. 10: A. 16: C. 20.

Dr. Girard first described this trout, giving it the name of *S. spectabilis*, but which I have been obliged to change, as there had already been described by Valenciennes, in his Hist. Nat. des Poissons, a species un-

der the name of *Salar spectabilis*. I cannot recognize the genera *Salar* or *Fario*, for reasons which have been given already in detail.

The *salmon-trout* of Puget Sound is a beautiful fish, varying in length from 10 to 24 inches. Its sides are profusely speckled with circular vermilion spots of about the same average circumference as a small pea. On the back of the fish there are several rows of the same sized spots, of a cream color. This trout is said to afford much sport; it certainly takes bait greedily, and would probably readily rise to the fly. They are found in the fresh waters from April till near Christmas, but are caught most abundantly during the months of October and November. The Puyallup, Dwamish, and Lummi Rivers, during three months, afford good fishing near their mouths. As a table-fish, this species, in my opinion, considerably surpasses the common brook-trout, which is saying a great deal.

A species of red-spotted anadromous trout is found in the rivers of Kamtschatka. According to Pallas it is known to the Russians as the *malma* or *golet*. In many respects it resembles the present species.

20. SALMO HUDSONICUS, Suckley.

HUDSON'S BAY TROUT.

SYN.—*Salmo hudsonicus*, SUCKLEY, notices of Certain New Species of N. A. Salmonidæ: N. Y., June, 1861.

SP. CH.—Head contained five times in the total length of the fish Dorsal outline strongly arched, its point of greatest height being at the first ray of dorsal. Head small and conical. Mouth quite small. Teeth small; a few on the head of the vomer; none on its shaft. Two rows of teeth on the tongue. Tail broad, and usually barred. In some specimens the bars appear to have faded out. Upper parts dark (bluish ?), sides brighter, belly white. The whole fish quite silvery. Scales small, but larger than in *S. fontinalis*. They are firmly adherent, and quite conspicuous. Flanks of adults above and below the median line covered with light spots about the size of peas—those in alcohol appearing as if they had been of a cream or orange color during life.

Integument over first ray of pectorals of a light orange or reddish color; that over the next ray dark. Female nearly similar.

DIAGNOSIS.—Would not be easily confounded with any Atlantic species except *S. fontinalis*, but has a smaller head, larger spots, and larger, more adherent, and thicker scales.

HAB.—Hudson's Bay and vicinity, (C. Drexler,) Labrador, (Elliot Coues,) Newfoundland, (T. Gill.)

Ray formula (of typical specimens,) Jar 3594, (Smith. Coll.) procured at Hudson's Bay by Mr. C. Drexler.

Original No. 433.—Br. 12 : P. 11: D. 10–11 ?: V. 8 : A. 10.

Original No. 168.—Br. 11–10 : P. 11 . D. 9–10 ? : V. 8 : A. 9.

Several young trout brought from the North by Messrs. Gill and Coues were at first supposed to be individuals of the *S. fontinalis*, which

had become somewhat altered in appearance by long residence in salt water. But upon the examination of Mr. Drexler's specimens from Hudson's Bay, it became apparent that a distinct, but nearly allied species exists thus far northward, replacing the above, and of which the specimens obtained by the first-mentioned gentlemen were the young. While in the salt water they bite freely at any common bait.

21. SALMO ROSSII, Richardson.

ROSS' ARCTIC SALMON.

SYN.—*Salmo rossii*, RICH. Nat. Hist., App. Ross's Voy., p. lvi;—IBID. F. B. A., vol. 3, p. 163; Pl. 80, Pl. 85, f. 2;—DEKAY, Zool. N. Y. Fishes, p. 242.
Salmo penshinensis, GILL, Cat. Fishes E. Coast N. A., p. 52.

SP. CH. [Condensed from Sir John Richardson's description.] Form more slender, dorsal outline less arched than in *S. salar*. Head also rather larger, being one-fifth of the length to end of scales on the caudal. Snout very obtuse; under jaw remarkably long, its tip having a small, incurved knob. [? No notch between the intermaxillaries for the reception of this knob.] Conspicuous pores on the sides of the face bones posteriorly. Eye equidistant between snout and nape. Intermaxillaries toothed along their whole margins. About thirty teeth on the tongue.

Ray formula.—Br. 12–13; D. 13–0; P. 14; V. 10: A. 11.

Scales very small—particularly on the back; nowhere tiled, each scale being surrounded by a distinct space of smooth skin.

Colors.—Back, top of head, dorsal and caudal fins have a hue intermediate between oil-green and hair-brown. Sides, pearl-gray, with a blush of lilac and silvery luster. Near the lateral line scattered dots or spots of carmine. Belly varying from faded-orange to tile-red, and arterial-red.

HAB.—Arctic Ocean, near the mouths of the rivers of Boothia Felix.

There does not seem to be sufficient reason for doing away with the name first applied to this species by Sir Jno. Richardson. Besides, the comparison of one or two dried skins, of nearly similar species ought to be insufficient to condemn a name once established.

This salmon presents peculiarities of great importance, which no red-spotted trout which we have seen—or in fact, any other, in a collection of 30 species of American *Salmonidæ*. Prominent among these may be mentioned the great number of teeth upon the tongue. The diagnosis between this species and others consists in the red-spots, obtuse snout, long under jaw, conspicuous pores on the face bones, the great number of teeth on the tongue, and the distinct space of smooth skin around each scale. All prominent and unmistakable characters.

22. SALMO HEARNII, Richardson.

COPPERMINE RIVER SALMON.

SYN.—*Salmo hearnii*, RICH. Franklin's First Journ., p. 706;—IBID., Faun. B. A. iii, p. 167;—DEKAY, Rept., p. 242;—GILL. Cat. Fishès E. Coast, p. 52.

SP. CH.—[Condensed from Richardson's description.] Form somewhat similar to that of *S. salar*, the head rather larger in proportion. Eyes small, situated opposite middle of labials. Intermaxillaries form a comparatively small portion of the margin of the mouth, and project somewhat. The lower jaw terminates in a small knob, (fleshy ?) which is received into a depression between the intermaxillaries. Teeth subulate. A solitary tooth on each side of intermaxillary notch. A few teeth on head of vomer, and a few stronger ones on the tongue.

Ray formula.—Br. 10: A. 10.

Caudal large and truncate with a slight rounding of the angles. Dorsal opposite ventrals. Between thirty and thirty-six cylindrical coeca. Scales firmly imbedded in a mucous skin, and very small.

Colors.—Back, olive green; sides, pale; belly, bluish; several longitudinal rows of flesh-red spots on the back and sides—larger on the latter.

HAB.—Coppermine River, in Arctic America. Anadromous.

23. SALMO ALIPES, Richardson.

LONG-FINNED CHAR.

SYN.—*Salmo alipes*, RICH. Nat. Hist., App. Ross's Voy., p. lvii;—IBID. Fauna. B.A.. iii, p. 169; Pl. 81; Pl. 86, fig. 1;—DEKAY, Report, p. 242;—GILL, Cat. Fishes E. Coast N. A., p. 52.

Salmo stagnalis, FAB., Faun. Grönl., p. 175, (Rich.)

SP. CH.—[Condensed from Richardson's description.] Form slender; dorsal outline comparatively straight. Head forms a little more than one-fifth of the total length; its upper surface convex, transversely and in profile; its cranial ridges prominent. Snout very obtusely rounded, receiving the knobbed extremity of the lower jaw in a toothless space. A projecting cluster of teeth on the knob of the vomer, the shaft of which is smooth and toothless. Teeth on the tongue disposed in two rows—six on each side—which are fully as large as those on the maxillaries. Pectoral, dorsal, and ventral fins very long—twice the length of the pectorals, reaching from the opercular opening to the middle of the ventrals. The ventrals, when turned back, almost touch the anus. Caudal forked. Scales small, thin, and adherent.

Ray formula.—Br. 11–12: P. 15: D. 13–0: V. 9: A. 10 or 11.

Lateral line formed of 126 scales, above which, at a point just anterior to the ventrals, there are 41 rows, and below 29, to the middle line of the body.

HAB.—Small lakes in Boothia Felix. Probably visits the sea.

The colors of this char, as given by Richardson, are obscure, as they were based on the appearance of a dried skin. There appear to have been yellow or orange spots along the sides. Lower parts white or yellow. We have been able to obtain no specimens for examination.

24. SALMO NITIDUS, Richardson.

THE ANGMALOOK.

SYN.—*Salmo nitidus*, RICH. Nat. Hist., App. Ross's Voy., p. lvii;—IBID. F. B. A., iii, p. 171, Pl. 82, fig. 1; Pl. 86, fig. 2;—DEKAY, Report, p. 242;—STORER, Synopsis;—GILL, Catalogue Fishes E. Coast, p. 52.

Variety of *S. alipes*, (RICH.)

The *Iviksarok* of the Greenlanders.

SP. CH.—[Condensed from Sir John Richardson's description.] Knob at point of lower jaw, received in notch between intermaxillaries. Back nearly straight. Teeth much as in *S. alipes*, as are also many other anatomical characters, for which see sp. ch. of *S. alipes* and "diagnosis" below. Lower jaw, when depressed, slightly longer than from snout to nape. Scales tiled, small, roundish.

Colors, (according to Captain Ross:) Body above the lateral line, deep green, softening towards the belly, which is of a beautiful yellowish-red tint posterior to the pectoral pin. Under parts white, slightly clouded by yellowish-red. On the sides several rows of red spots, principally distributed between the lateral line and the yellowish red of the belly, varying in size, the largest being as big as a pea. Dorsal fin like the back. Under fins dusky-red, the anal paler, and the first rays of the pectorals, ventrals, and anals white.

Ray formula.—Br. 11–12; D. 14–0; P. 17; V. 10; A. 12.

HAB.—Small lakes in Boothia Felix. (Richardson.)

DIAGNOSIS.—In many characters this fish agrees with the *S. parkei*, *(nobis,)* found in the head-waters of the Columbia, west of the Rocky Mountains. The latter has more branchiostegals, and also light-green spots on the back, not noticed in the description of *S. nitidus*. From *S. alipes*, Richardson gives the following distinctive characters: Body thicker than that of *S. alipes;* belly more prominent, fins shorter, anus farther back; head less arched above and in profile; mesial ridge and lateral porous curves less prominent; no radiating lines above the orbit, which is proportionately nearer the snout; upper jaw shorter.

This fish, the *S. alipes*, *S. bairdii*, and *S. parkei*, agree in possessing characters almost sufficient to include them in a distinct subgenus. They all belong to the chars, (subgenus *Salvelinus* of Nilsson,) but in addition have an elongated, fleshy projection standing up from the point of the lower jaw, which is received into a toothless notch between the premaxillaries. They, in addition, have a mark common also to the *S. fontinalis*, Mitchill; this is in having the first rays of the pectorals, ventrals and anals yellow, red, or white. None of the black-spotted trouts, or salmon, have these rays in color specially distinguished from those of the rest of the fin.

When we speak of color of the ray, we mean of the integument or membrane covering it.

25. SALMO FONTINALIS, Mitchill.

COMMON TROUT; BROOK TROUT OF THE ATLANTIC COAST OF NORTH AMERICA.

SYN.—*Salmo fontinalis*, MITCHILL, Trans. Lit. & Phil. Soc. of N. Y., 1, p. 435;—RICH. F. B. A. iii, p. 176;—KIRTLAND, Report, Zool. Ohio, pp. 169–194;—THOMPSON, Hist. Vermont;—DEKAY, N. H. State of N. Y., Fishes, p. 235;—AYRES, Bost. Journ. N. H. iv, p. 273;—KIRTLAND, Bost. Journ. N. H. iv, p. 305;—VALENCIENNES, H. N. des Poissons, xxi, p. 266, 1848;—STORER, Synopsis;—BIGELOW, Bost. Journ., vi, p. 49;—FORSYTH, Bost. Journ., v, p. 412;—HERBERT, (Frank Forrester,) "Fish and Fishing;" also, "Supplement to the same;"—GILL, Cat. Fishes E. Coast N. A.
Salmo nigrescens, RAF. Ichth, Ohien, p. 45.
Salmo erythrogaster, DEKAY, Report, p. 236.—(Red-bellied variety.)
Baione fontinalis, DEKAY, Rep. Fishes, p. 244, 1842. (A species founded on the young.)
Salmo canadensis, HAM. SMITH, "Grif. Cuv., vol. 10, p. 474, Pl. 41."—DE KAY, Rep., p. 243.—Storer Synop., p. 197.
Salmo fario, SMITH, Fishes of Massachusetts, p. 141.

SP. CH.—[Mostly condensed from DeKay.] Body oblong, compressed; back, broad and rounded; head, sloping nearly symmetrically above and below; nostrils double; labials, intermaxillaries and lower maxillaries armed with minute teeth; tongue with two rows of from four to six teeth; vomer, with six to eight teeth in a single row. Br. 12, 12.

Colors.—Above with irregular dark markings on a horn-colored ground, which, in freshly caught specimens, give bluish and greenish metallic reflections; sides lighter, merging into silvery-white on the abdomen, but showing much red in the spawning season; upper part of the head dark greenish-brown, with obscure mottlings; vermilion dots and large yellow spots in the vicinity of the lateral line. The pectorals have the first ray yellow or the second black, the remainder orange; ventrals and anal with first ray white as on the tips of second and third. Caudal reddish, with obscure parallel dark bands, more distinct toward the tips of the lobes. Caudal somewhat emarginate; quite forked in the young, which have also dark transverse bars on the sides.

HAB.—Fresh-water lakes and streams from Canada to Tennesee on the Atlantic slope. Occasionally repairs to salt or brackish water if within reach.

Among some fifty specimens of this species of trout in the Smithsonian collection are individuals from Eastern Tennessee; Preston County, Virginia, (Professor Andrews;) from the Potomac River; from various rivers and streams in Pennsylvania, New York, and the New England States, Lake Superior, and Canada.

Notwithstanding the great range of the species there is but little sign

of local variety, except what may be caused in color by change of position from still to rapid or fresh to brackish or salt water, to which the species is very fond of repairing when accessible. The more southern specimens are paler, while those from Lake Superior and Canada are darker than is usual in the Middle States. This must be owing to some natural law affecting the Salmonidæ. The New Mexico specimens of *S. virginalis* in the Smithsonian collection show the same bleaching when obtained from southern localities. The *S. erythrogaster*, DeKay, is nothing but this fish tinged with red during the breeding season. This is the favorite game-fish of the Middle States, where its capture during the proper season is one of the most keenly-relished sports of our scientific anglers. Its weight rarely exceeds four pounds, and it is rare indeed to find one in Southern New York weighing more than three. The mountain streams, which are the sources of the Delaware, are favorite resorts of anglers, where large numbers are taken without difficulty, but unfortunately they are usually of small size. On Long Island much larger fish are taken. There are there—especially on the south side—many fine private ponds, where trout are carefully preserved and their management reduced to a specialty. Many of these ponds are owned or leased by fishing clubs. Stringent rules exist against the destruction of fish below a certain size, or the killing of more than a limited number daily. Probably the finest and best preserved trout-pond on the island, Massapequa, belongs to William Floyd Jones, esq. The writer can testify to the excellence of the fishing there, the large size of the fish, and the genuine hospitality of the proprietor. John D. Jones, esq., at his country-seat on the north side of the island, has several artificial ponds in which, at the time of writing, (June, 1861,) he is experimenting in the artificial raising and maintenance of this beautiful fish.

The following interesting remarks on the habits of *Salmo fontinalis* are extracted from a letter addressed to Dr. Storer, by I. B. Forsyth, M. D., published in the Boston Journal of Natural History, vol. v, p. 412.

"The few observations I have to communicate upon the habits and peculiarities of the salmon-trout, were made during a residence of ten years in Sandwich, Cape Cod, where the facilities for that purpose are very abundant.

"It may be well to premise, that the distance, at this point of the cape, from one bay to the other, varies from five to ten miles, and the land is gradually elevated from each shore, till it reaches the center, and consequently the streams, for the most part arising from springs, are short, terminating in creeks upon the marshes. Many of these are of sufficient magnitude for mill-sites, and are therefore crossed by permanent obstructions; and hence it frequently happens, in the short space of a quarter of a mile, you find specimens of both, as they are familiarly

called, the fresh and salt water trout. The following varieties in color and appearance have been observed:

"1st. Those having the upper part and sides of a pale brown, gradually becoming less so, till it terminates in white on the under part, having a silvery appearance when first taken from the water, and covered with small, distinct scales; the circular yellow and red spots very indistinct; generally found in the marshy creeks, or in open streams, where the sun has free access. They are well fed upon minnows and shrimps, having a plump appearance, and are the variety mostly sought after by those who desire the trout in its highest perfection, for the table. They are taken mostly between the months of January and July. They vary in size from one-fourth of a pound to four pounds; but I have never seen one to exceed two and a half.

"2d. Those having the upper part and sides of a dark brown, having a dark-green appearance, terminating in white or orange underneath, and covered more or less with round yellow spots, with a bright red center, color varying according to the location; and generally not so plump and well fed as those above mentioned.

"3d. Those having the upper part and sides of either a light or dark brown, with spots more distinctly marked on the dark than the light; underneath, the color uniformly ferruginous or orange.

"Each of these varieties is found both in the streams communicating with the salt marshes, and in those which are entirely cut off from them, by permanent obstructions. The first-named variety, however, is nowhere found in so great perfection as in close approximation to the salt creeks. The difference between the salt and fresh water trout, in this vicinity, seems to be only in name, so far as I have been able to determine, with ample opportunities in taking them, and with specimens before me.

"The peculiarity of these varieties seems to depend entirely upon the location and the nature of the soil at the bottom of the stream they inhabit. The first variety is found in clear water, with light gravelly bottom, and where the banks are not shaded by shrubbery, but where they are almost constantly exposed to the rays of the sun. The second variety inhabits streams which are for the most part shaded by trees, or which take their rise in, or pass through, peat-bogs. Thus in one stream, the trout caught at the head of it were always of a very dark brown, almost black, highly marked with yellow and red spots, while those taken near the mouth of the stream were of a light color. One of these streams arises from a deep basin of dark water 30 feet in diamete and 10 feet deep, surrounded by a peat-bog, where fish taken, so far as I know, have been uniformly of a dark brown. In other streams having a bottom of iron ore they are uniformly marked with orange underneath, the color of the upper part and sides appearing to depend upon the amount of exposure to the sun's rays. These observations are made independent of any of the changes of color or markings which take place during the spawning season.

"About the 1st of January these fish are found congregated together at high-water mark, and seem to have come down the stream for the purpose of locating themselves in the marshes, where they can obtain food. So uniform are they in this that, for a number of years it was my custom to visit one particular stream during this month, and I was always sure to find them assembled in waiting for me within a few rods of the same spot, in number I cannot say how many, but I would take of them varying from sixty to seventy-five.

"During the months of February, March, and April they become separated and are distributed the whole length of the creeks, and about the 1st of May begin again, in small numbers, to ascend the stream. This they continue to do as the season advances, and this means of sustenance increases (which is principally insects and flies) till about the middle of October, when they are found in great numbers, as near up as they can conveniently get to the origin of the stream. This is their spawning season, and having deposited their spawn, they begin to wend their way down the stream, for the most part in a body, till they reach again the marshes.

"These fish were formerly taken in considerable numbers with a kind of net used in the herring fishery; but this mode of taking them is, I believe, prohibited by legislation. They are now taken, for the most part, with line and hook, baited with minnow, shrimp, or earth-worm; or, at some seasons of the year, with the artificial fly, more especially in the fresh ponds. Two other methods of taking them have been resorted to in the small streams, both of which deserve a passing notice. The first is by titillation, so-called; and the second, hooking them up by the caudal extremity, decidedly the meanest way of taking them.

"The method of taking them by titillation is this: About the spawning season they are found, for the most part, in the small and narrow head streams, and seem more sluggish than at any other season of the year, and less inclined to take the bait. Having arrived at the edge of the stream the hand is carefully and gently passed along under the banks until it comes in contact with the fish, generally near the tail.

"The titillation then commences, and the hand is made to approach toward the head till sufficiently forward to prevent slipping through the fingers, when by a sudden grasp it is landed upon the shore, the fish remaining perfectly quiet during the process. This mode of taking them I have practiced in one stream three years in succession, and taken many fine trout. The unscientific mode of hooking them up by the caudal extremity is also practiced at the spawning season, when they are averse to taking the bait, and where the stream is deeper and wider. The manner is as follows: A large-sized hook, made very sharp, is fastened to the end of a long straight stick or piece of whalebone. The fish is then sought and generally found beneath the root of an old tree, or under the shadow of a log, with the head and part of the body out of sight; the hook is then carefully introduced near the

extremity of the fish, and by a sudden jerk is inserted so as effectually to secure him."

We also copy an extract from the Journal of the Bost. Soc. Nat. Hist., vol. vi, p. 49, a paper entitled "Observations on some of the habits of *Salmo fontinalis*. By Samuel L. Bigelow, M. D."

"The following observations on the habits and peculiarities of a species of *Salmo* were made in a comparatively short space of time, without reference to science, but merely as a source of pleasure to myself, and to gratify a natural curiosity. The pond in which these trout are found is situated at the base of the northeast ridge of the Monadnock Mountain. It covers an area, I should think, of seventy-five or one hundred acres, and is so deep about the center that soundings have not been found, though a line has been sunk 200 feet. It is supplied entirely by springs at the bottom, which is composed of red and white sand and rocks, so far as the depth of the water will permit of an examination. The water is always very cold, and so clear that the bottom may be seen in a bright day to the depth of 25 or 30 feet; and although there are neither inlets nor outlets, its height is nearly the same at all seasons. Its depth increases from the shore, where it is only a few inches, in some parts gradually, and in others rather abruptly.

"The form of the pond is quite irregular and has been fancied by some to correspond very exactly to the base of the mountain, which is close beside it. From this circumstance, together with its great central depth, has arisen a legend of its having been once filled by this mass, now a mountain, which was heaved out by some convulsion of nature. The southwest shore is more stony and less exposed than almost any other, and here it is that the trout form their beds and come to spawn. Another natural advantage which this point possesses over others is, that here the change from shallow to deep water is quite abrupt, affording the trout a better chance for escape in case of fright or danger.

"Their beds, as they are called, are merely small cavities formed by the accidental position of three or four stones sunk to their upper surfaces in sand. Their capacity is generally from a pint to a quart, and their forms are various; sometimes flat and shallow. They are most numerous within 10 feet of the shore, and in not more than 10 or 12 inches of water. The trout having selected these little cavities, clean them out with care, removing the finer particles of dirt by fanning with their tails and the larger with their mouths; this done, they have a bed which they visit for a successive series of years, which will be longer or shorter, as they are more or less disturbed. An old fisherman pointed out to me abandoned beds on which he had in former years taken great numbers. They were on the south side of the pond, whence the fish had gradually followed the shore till the year before last, when they came up on the extreme southwest shore, where I found them. They remain in the deep water about the center of the pond during the entire year, except the spawning season, which commences about the 1st of October.

So precise are they in their time of appearing that this fisherman has for the last six or eight successive years taken fifty or seventy-five pounds on the first day of October, when even the day before he could neither see a trout or get a bite. They failed, however, to be thus regular last season. The first four days of October were quite warm and rainy, and with almost constant fishing we caught only ten or fifteen pounds during that time, and those in water of 20 or 25 feet in depth. This proximity to the shore, however, showed them to be approaching their beds, and a few cold nights brought them up.

"The unusual mildness of the season causing too great a difference in the temperature between the deep water they inhabit and the shallows on the border, may be the cause of their late appearance. But it was no easy matter to make a convert of the old fisherman to this doctrine; he held firmly to his old notion that 'they had a wonderful sight of almanac learning;' they had only 'missed their reckoning.' Having reached their beds they lose almost entirely their natural cautiousness and shyness, and seem wholly absorbed in the object of their visit, endeavoring in turn to reach a bed which they remain upon till their ova are deposited. If frightened by a sudden or violent motion of one standing on the shore, over them as it were, they reluctantly retire a little distance, but almost immediately return. The males follow the females closely at this time. They are, I should think, about in the proportion of one male to four or five females. I was in the habit of disturbing them daily, from sunrise till dark, and prevented them to a great extent from remaining quiet long enough to spawn; so they were compelled to come up in the night in order to go through with their labor undisturbed. In the females, which I took the day before they began to spawn at night, I found the membranes enclosing the mass of ova ruptured, and a continuous line of single ova extending from the mass through the passage and stopping directly within the external organs, which were very red and much swollen. The spawning season lasts, I think, for two or three weeks, after which they retire again to the deep water, where they can be taken only in the winter through the ice. Generally, in spawning time, there is no difficulty in taking them with a baited hook; but last season, perhaps owing to their being late, and pressed to the performance of their functions, they passed all kinds of bait and hook untouched. In the winter the only bait used is the minnow; but in October, it is various, as the grasshopper, angle-worm, and artificial fly. These are most used; but I found that when they passed all these they would often take readily to their own spawn, dried a little in the sun. Another means of taking them at this time is by a slip-noose of strong wire attached to the end of a short pole. This is passed over the tail or head, it matters little which, they are so careless at this time, and carried to the center of the body, when a strong and sudden pull will bring them to the shore. Another mode of catching them is by means of a large hook attached to a short pole and line. This is carried under the fish, and secured in the body by a sudden jerk which lands the fish on shore.

"Four hooks are sometimes used, bound together by the shanks in such a manner that the points are presented at right angles to each other. If these are dropped among a number there is a chance of securing more than one; and if a single fish is the object, his chance of escape is made less. These are both easy methods. At this time they do not seize the bait with the suddenness of the common brook-trout; they take it calmly and retire deliberately like the perch. They vary in size from one quarter of a pound to five pounds; but those taken are seldom less than one quarter or more than three pounds. The larger ones are taken almost exclusively in the deep water, through the ice. The males are of a very brilliant and shining dark-brown olive color on the back. The sides are brilliant and silvery and are traversed by a longitudinal line and covered with very bright red and yellow spots. The belly is perfectly white. There are some spots on the fins, but I cannot say on which, nor if all are spotted, nor do I know the precise number of spots. The females are less brilliant than the males; the back is lighter and more dingy; the sides are less silvery, and the spots are fewer and less bright. Several females that I took were of a yellow-brown color and darker on the back than on the sides, with a yellowish-white belly. They were mottled and looked as if water-soaked. These trout, as a whole, were much more silvery and brilliant, and had more and brighter spots than most brook-trout. Their flesh is red, but not so dark as that of the salmon. There is but one other kind of fish found in this pond, viz, the perch. They live in an entirely distinct part from that occupied by the trout; and I think they are never seen or taken together. The perch are only about the northeast shore, which is quite rocky. The trout have been taken in this pond, as far as I could learn, from time immemorial, and formerly in so great numbers, to use the language of the old fisherman, as to 'have been fed by bushels to the hogs.' This is by no means the case at the present day."

26. SALMO IRIDEA, Gibbons.

PACIFIC BROOK TROUT.

SYN.—*Salmo iridea*, GIBBONS, Proc. Cal. Acad. Sc. i, 1855, p. 36;—GRD. vol. x, P. R. R. Reports. Pl. lxxiii, fig. 5; Vol. xii, part 2, Pl. lxxiv.

Salmo rivularis, AYRES, Proc. Cal. Acad. Sc. i, 1855, p. 43.

Salar iridea, GIRARD, Pr. Acad. Nat. Sc. Phil. viii, p. 220, 1856;—IBID. Pacific R. R. Reports, x, p. 321.

Fario stellatus, GRD. Proc. A. N. Sc., Phil., viii, 1856, p. 219;—IBID. P. R. R. Report, x, p. 316;—SUCKLEY, (by oversight retaining the word "Fario,") P. R. R. Rep. xii, p. 346; also, Nat. Hist. Wash. Ter., 346, pl. lxix, figs. 5–8.

SP. CH. Head large, its greatest length measured to edge of operculum, being contained about four and a-half times in the total length; usually a double row of teeth along the shaft of the vomer; dorsal outline but slightly arched; tail strongly forked; lateral line about in the same plane as the centre of the eye.

Colors.—Back, brownish olivaceous, with bright silvery reflections; lower parts silvery white; fins orange or red. Head and opercula profusely spotted with round black spots, numerous to the tip of the snout, all along the top of the head, above the eyes; the gill-covers scarcely as numerously or regularly spotted as the other parts. Back and sides freely spotted with black spots of irregular shape, some being star-shaped, others X-shaped; more numerous and irregular near the tail. Dorsal, adipose, and caudal profusely spotted with oval. Scales firmly adherent.

DIAGNOSIS.—From *S. lewisi* by its large head, more slender form, much larger scales, more numerous spots, and more forked tail. From *S. virginalis* by its strongly forked tail and spotted head; anal destitute of spots. From *S. masoni* by its small scales. (For further diagnosis see those species.)

HAB.—Streams along the west coast of California northward. The foregoing summary of specific characters was based on a specimen labelled by Dr. Ayres, of San Francisco, as belonging to his species *S. rivularis*; on a large specimen from Chico Creek, California; on two obtained at the Dalles of the Columbia; and on one obtained from the Deschutes River, Oregon. These have been selected as type specimens out of a vast number from the same and intermediate localities. All the true brook-trout found west of the Mississippi are distinguished by their black spots, the red spotted being either lacustrine or anadromous, and therefore hardly coming under the name "brook-trout," although often ascending streamlets to spawn.

Two varieties of the *S. iridea* seem to prevail, as follows:

First variety.—In general shape and form resembling the type of *S. iridea.* Colors pale, the fish having a washed appearance. Spots on a caudal and dorsal faint. Half a dozen specimens were sent from San Mateo, California, by Mr. R. D. Cutts. The type of this variety is entered in Mus. Catalogue Fishes, 597, labelled "variety *lavatus.*"

Second variety—stellatus.—The star-spotted trout. This was described by Dr. Girard as a distinct species, under the name of *Fario stellatus.* Most of the specimens I have examined have a double row of teeth on the vomer. It is principally distinguished from the type form of *S. iridea* by the greater profusion, size, and irregularity of its black spots. The young frequently show large spots, of a more regular roundish shape. It may be one of the effects of age in the species *iridea* that the black spots fade out. The same seems to occur in individuals of the species described by us as *S. brevicauda.*

As a comparison of the relative size of the heads of the black-spotted trout seems to furnish valuable data for classification, the following table has been introduced. Two sets of measurements are given, the one showing the number of times the length of the head, when measured from snout to the scales at the nape, is contained in the total length of the fish; the other when the head is measured from the snout to the

farthest point on the free margin of the operculum, and the number of times it is contained in the total length.

Table showing the comparative size of the heads of the different species of Black-spotted trout.

Catalogue, No.	Name of species.	Locality.	Head contained in total length of fish.		Collected by—
			Measurement taken from tip of snout nape.	Measurement from tip of snout to the farthest point on free margin of operculum.	
592	Salmo lewisi*	Falls of the Mo. R.	8.25	5.25	Dr. Suckley.
592	Do.	Do.	8.25	5.25	Do.
3326	Do.	Do.	8.25	5.20	Dr. Cooper.
3327	Do.	Do.	8.75	5.20	Do.
30–31	S. virginalis,	Fort Mass., N. M.	7.10	4.50	Dr. Peters.
31–31	Do.	Do.	7.35	4.75	Do.
30–31	Do. *	Do.	7.35	4.50	Do.
30–31	Do.	Do.	7.20	5.00	Do.
595	Do. young	Utah Creek, N. M.	6.75	4 50	Lt. Beckwith.
595	Do.	Do.	6.90	4.65	Do.
595	Do.	Do.	6.95	4.65	Do.
597	Salmo iridea	San Mateo Cr., Cal.	6.75	4.40	R. D. Cutts.
597	Do.	Do.	6.75	4.50	Do.
595	Do.	San Francisco.	6 50	4.60	Dr. Newberry.
27	Do. (rivularis)	San Francisco	6 20	4.40	Dr. Ayres.
594	Do. iridea	Chico creek, Cal.	6.25	4.25	Dr. Newberry.
596	Do.	Humboldt Bay	6.30	4.60	
1123	Do.	Dalles, Oregon	7.30	5.25	Dr. Suckley, skin, P. mark.
584	? Do.	Ft. Steilacoom	7.25	5.00	Dr. Suckley.
590	Do.	F. Dalles.	6.90	5.00	Do.
586	Do. brevicauda	Nisqually Creek	7.50	5 00	
586	Do.	Cape Flattery	6 30	4 75	Lt. Trowbridge
586	Do.	Do.	6.50	4 50	Do.
H	Do.	Puget Sound	6.75	4 50	
	Do.	Do.	7.20	4.75	

*Typical specimens.

This fine trout upon the Pacific slope replaces the *Salmo fontinalis* or the delicious red-spotted brook-trout of the Atlantic States, so much prized by both sportsmen and epicures. The fishing is very fine in nearly all the rapid streams of the Coast and Cascade Mountains of Oregon.

At Fort Dalles, O. T., trout-fishing is good in April, May, June, and July. Many of the rapid snow-water streams descending from Mount Hood abound in delicious fish of this tribe. But all pleasures have their drawbacks, and in this region, after the sunflower blossoms in spring, Piscator must look sharply when fishing, for other kinds of bites than trout-bites, namely, those of rattlesnakes. The great number of these infernal reptiles about Fort Dallas actually interferes much with the enjoyment of angling. These streams have another disadvantage; they are so thickly lined by cotton-woods, willows, and squaw-bushes, that it is very difficult to find positions where the fly can be successfully cast. Where this can be done, the trout rise boldly, and take it greedily, and the fish themselves are active, plump, and delicious, affording good sport. Owing, as above stated, to the dense brush along the banks of these waters, fly-fishing is generally impracticable. The angler is therefore obliged to resort to "bait-"fishing, which, indeed, has its pleasures, too, as, "old Izaak" has testified.

There are few angle-worms in Oregon or Washington, perhaps *none*. The writer has never been able to find them there, yet they will probably be hereafter introduced by civilization. (Introduction of certain worms, bugs, &c., the concomitants of civilization, into new countries by civilized emigrants, is by no means uncommon. Examples of this are given by Darwin in his remarks on New Zealand; *vide* Voyages of a Naturalist.)

Common raw meat is a very good bait for these trout—the tougher the better; we generally used the meat of a crow, killed for the purpose. This flesh combines redness and a rank smell with its proverbial toughness—all-important desiderata for "killing" bait. Grubs and the larvæ of wasps are also good bait, but troublesome. When the fish are capricious we have frequently found good sport by trolling with one of the belly-fins of a fresh-killed fish.

On Puget Sound, in the vicinity of Fort Steilacoom, the writer had the best sport. A much longer residence taught him the "ropes" better; and besides, the rattlesnake was absent. Nearly every stream and brook abounds in trout; all, except the salmon-trout, not yet described, of the black-spotted species. Here we noticed many peculiarities distinguishing this fish in habits from its Atlantic congener. Although fond of running water, it seeks the more deep and less turbulent portions of the stream, and it even does not eschew perfectly still water. When a youngster, we learned and practiced trout-fishing in those beautiful tributaries of the Delaware, the Beaverkill, and Willa-weemock, in Sullivan and Delaware Counties, New York. There the trout delight in fierce water, and if found below a violent rapid, or a waterfall, they may be caught almost always just outside the strength of the current, but not by any means are they fond of the *still* water, a little farther below the rapids, unless, indeed, the weather be very cold; or if in summer, during the shades of evening, when they repair to the more placid water, that they may the more readily perceive insects and other floating food. But in Washington Territory the brook-trout seems more fond of moderate currents, or of places that are perfectly still, where the waters are well shaded and deep; and it is rare indeed for the angler to have good sport at the immediate foot of a rapid or fall. One of the best spots for trout-fishing in the neighborhood of Fort Steilacoom is a small portion of the stream running through "Melville's claim," near the "Government garden." This place is where the water of the stream is very sluggish, and almost choked up by lily-pads and grass. There are here but few trees, and the brook only averages 15 feet in width by about 4 in depth. The space in which throwing the line is practicable is but of limited extent, certainly not exceeding 75 yards in length. Here one day in August, 1856, we took twenty-five trout, the weight of the fish running from four ounces to a pound. Bait and flies were both used. Nearer the fort—even within sound of its drums—there is a small isolated lake, without outlet, and fed by a small spring. This lake be-

comes almost dry in summer. It is full of trout; how they ever got into it is a mystery. Here, seated on a half-submerged log, we have caught many a fine bunch of "speckled bellies." Flies do the best there, especially late in the afternoon, and until it becomes so dark in the evening that the angler cannot see his fly break the water. After this time, unless he has artificial *white* moths, the fly must be put aside, and then the anal fin, or a piece of the belly of a fresh-killed fish, gently trolled near the surface, will frequently hook "big ones."

Steilacoom Creek, below "Chambers's Mill," is an excellent place for trout in January, February, and March. Here the waters rise and fall with the tide, and are fresh, brackish, or salt, all within the space of half a mile. The writer has there caught several male trout, weighing, two hours after killed, over two pounds each. The two largest were killed in February, 1854, with a large, unnatural, gaudy salmon-fly. Fish of large size are rarely taken in this place later than March; after that they are replaced by vast quantities of small ones, rarely exceeding 7 inches in length, which, although excellent for the table, certainly afford no sport.

Although there are other good spots, such as the Turnwater Falls, near Olympia, Clark's Creek, near the Puyallup, and many more that could be mentioned, the writer will confine himself now to the consideration of but one more good fishing-ground, and then bid the geographical portion of the article good-bye. This last place is McAllister's Creek, situated about eleven miles from Fort Steilacoom, and nine from Olympia. It affords the best trout-fishing we know of in the Territory. Perhaps there are no more fish here than in many other similar water-courses in the neighborhood, but it has the advantage of having good banks, only moderately shaded, from which casts can readily be made. The best portion of the fishing-ground extends from the old mill-site to a point about three quarters of a mile below. This is all subject to tide influence, but the water is fresh for the greater part of the tract, and even at the lower end is but slightly brackish at high water. The best time for fishing in this creek commences about an hour and a half before high water, and lasts three-fourths through the flood-tide. In one day's fishing in October, 1856, the writer caught, at this place, thirty-eight fine trout the aggregate weight of which, six hours after death, was fifteen pounds. The bait used on that day was principally salmon-roe, one-third dried, but we have frequently taken many fish, in the same place, with artificial flies, grasshoppers, meat, and most of the other ordinary allurements. To such of our readers as may probably condemn the unsportsman-like practice of fishing with salmon-roe, meat, or grasshoppers—to those who have no patience with any other mode of trout-fishing, except by the scientific whippings of an artificial fly—we must apologize by saying that our only fly-rod was irretrievably broken, our flies were gone, and it was nearly a thousand miles to the nearest fishing-tackle store.

In the streams near Fort Steilacoom there are probably many in-

dividual brook-trout which will weigh as high as three or four pounds; but owing to the want of tackle, &c., already alluded to, the writer was never fortunate enough to secure any fish that exceeded a trifle above two pounds.

One peculiarity about the northwest trout is, that the fish remain in good condition for the table until near Christmas, at which time they begin to spawn. On the contrary, the trout of the Middle and New England States spawn during the months of September, October, and November, and may scarcely be said to be in good condition between the 1st of September and the 1st of February, being, during the interval, lean, flabby, and insipid.

The black-spotted brook-trout of the northwest is by no means dependant upon occasional access to salt water, although he seems to avail himself of its invigorating effects when practicable.

In a lake near Bellingham Bay, and also in Chiloweyuck Lake, trout of this species or its relative, the *brevicauda*, are said to attain a weight of ten or twelve pounds; and in the latter lake according to Lieut. D. B. McKibben, of the United States Army, the common weight of the fish caught will scarcely fall below three or four pounds.

27. SALMO MASONI, Suckley.

MASON'S TROUT.

SYN.—*Fario clarkii*, GRD. [*non Salmo clarkii*, RICH.] *Vide* Proc. Acad. Nat. Sc. Phil., viii., p. 219, 1856; also P. R. R. Rep., Gen. Rep., Fishes, vol. x, p. 314, Pl. lxxi, figs. 5–8.

Salmo masoni, SUCKLEY, Pacific Railroad Reports, vol. xii, p. 345;—IBID. Nat. Hist. Wash. Terr., p. 345.

SP. CH.—Head forms nearly a fifth of total length. Dorsal outline well arched; back dark olivaceous; sides silvery; belly white; the whole sprinkled with small irregular spots of black, which, however, are more faint than in *S. iridea*, as if the coloring matter was placed deeper below the surface; scales large; tail forked; upper fins and tail spotted

DIAGNOSIS.—It may be known from *S. iridea* by the absence of red patches, also by its fainter spots, more convex dorsal outline, and larger scales, nearly double in size to those of the *iridea*. From *S. brevicauda* the diagnosis is more difficult; but in the latter the scales are very loose, and the tail more encroached upon by them.

HAB.—Small streams entering into the Columbia. This fish may prove to be simply a variety of *S. iridea*, which, beyond a doubt, exists in the waters of Oregon and Washington Territories.

Dr. Cooper caught in the Katapootl River the specimen (No. 582) from which Dr. Girard drew his description of *S. clarkii*, and upon which the description of the present species is based. The *S. clarkii* of Richardson is a very different fish, probably an anadromous salmon. The habits of this fish are almost precisely similar to those of *S. iridea*.

On the 13th of August, 1859, Mr. Gibbs obtained a trout on the Ska-

git River which we have referred to *S. masoni.* The total length of this fish was 12.75 inches, and the distance from snout to dorsal fin 5.75.

"*Colors.*—Back and sides above lateral line sprinkled with small spots of irregular shape, black on the back, on the sides *blue*, with a black edge behind. Behind the anal spotted below the line. Sides, as far back as anal fin, with a broad streak of lake-red. Dorsal and caudal spotted with black. Back, dark brown, approaching to black, with blue reflections. Belly, yellowish-red. Head partly spotted above, on the snout and on the preopercula.

"Head, short and blunt. Tail, slightly lunated. Another specimen had small specks along the belly, and the colors were lighter, with more red.

"Much larger specimens were taken, but the meat in every instance was *white.* Mr. Gibbs obtained a fish, apparently similar, from the waters of the Sunilkamun, flowing into another basin; but this had red flesh, and lacked the broad streak along the sides. [This latter is probably an effect of age or sexual excitement.] The lateral line was red."—Gibbs' Mss.

Two species of trout were taken in the mill creek, east of the Columbia, at Fort Colville, through the ice. One, with red flesh, is known as the *humāāna*, and is the larger—(*S. gibbsii* ?) the other is the *peestl*, and is the common black-speckled brook-trout. "Again," Mr. Gibbs remarks, "the Indians say that the *Peestl* has the dashes of carmine under the jaws which the *Humāāna* lacks. They also say that it is the male fish which has a reddish tinge on the belly." * * * On the 2d of April "found the Indians at the crossing of the Little Spokane taking the *Humāāna* in small numbers. A female had the roe entirely developed."

28. SALMO VIRGINALIS, Girard.

UTAH TROUT; SOUTHERN ROCKY MOUNTAIN TROUT.

SYN.—*Salmo (Salar) virginalis*, GRD., Pro. Acad. Nat. Sc., Phil., viii, 1856, p. 220;—IBID., P. R.R. Report, vol. x., p. 320;—SUCKLEY, Appendix Rep. Fishes, Nat. Hist. Wash. Ter.

SP. CH.—[Drawn from a large number of specimens in the Smithsonian collection.] Body rather slender; dorsal outline but slightly curved; tail broad and but little cut out; black spots on sides of body and on back; posteriorly somewhat stellate and numerous; anteriorly scattered, distinct, and round; top of head unspotted; anal fin spotted with black; extremity of maxillary extends to a vertical line drawn from the posterior rim of the orbit; anterior margin of dorsal nearer the extremity of the snout than it is to the insertion of the caudal.

Colors.—[Taken from living specimens by the writer.] Ground color of the back pale brown, tinged with red, sprinkled on back and sides with small black spots, most numerous and irregular posteriorly; anterior half of the body, with those spots scattered sparsely, and quite round

in shape; under parts white and but little spotted. [See description in detail beyond.] Anal-fin spotted, pied chin, patches on the cerato-hyals.

Fig. Plate lxxiii, Pacific Railroad Reports, vol. x. (Part embracing Lieutenant Beckwith's Report.)

HAB.—Southern Rocky Mountains, Utah, New Mexico.

DIAGNOSIS: From *Salmo lewisi.* See text relating to the latter species. From *S. iridea* it may be distinguished by its usually smaller head, the absence of dark spots on the top of the head, the profusion of which in that situation in *S. iridea* being a notable feature of the species; the sparsely scattered, large, round, black spots on the anterior portion of the body; their distinctness and regular shape distinguishes them from the more numerous spots of the latter species. The tail of this species in the adult is nearly even at its fore margin; that of an adult *S. iridea* is well forked.

A trout sent from Santa Fé, N. M., preserved in the Smithsonian collection, shows slight variations from those received from Northern New Mexico, Utah, und Nebraska. It agrees with the *S. virginalis* in many characters; in fact, in all essential points, such as the dorsal profile, size of head compared to body, &c., &c., and in general plan of coloration. It is, however, a brighter or more silvery-looking fish; its dark spots smaller and less numerous.

Dr. Girard first described this species from a young trout sent from Utah Creek, a tributary of the Rio del Norte, by Lieutenant Beckwith.

A variety of the *Salmo virginalis* occurs in Lake Utah, a large sheet of fresh water about fifty miles south of Salt Lake City. The fish are less spotted than those caught in the mountain streams near by, and attain a much larger size. They ascend the Timpanagos River for spawning purposes; at the proper time, according to the accounts of the Mormons, leaving the lake simultaneously in great numbers. They are said to be occasionally seen a yard in length. A friend—Lieutenant Williams, of the United States Army, caught one of this kind in the Timpanagos, about seven miles from the lake, which weighed seven pounds. I myself have caught smaller fish in the same stream, which varied considerably from those caught on the eastern side of Bear Mountains.

In the Smithsonian collection two fish, obtained by Captain Simpson, United States Army, seem to be of that variety. They are simply labeled as from Utah, and appear to have been salted and dried before being thrown into alcohol.

For this variety or kind we will, for the present, apply the provisional name of *Salmo utah.*

CHARACTERS.—Highest point of convexity of dorsal profile rather anterior to the same on *S. virginalis;* scales appear somewhat larger, (but this may be more apparent than real, owing to the insufficient material for comparison;) appearances of fish more silvery, spots much smaller in size and more irregular in shape; in other respects resembling *S. virginalis.*

In 1859 the writer crossed the continent via Salt Lake. In the course of this journey many notes were made concerning objects of interest in nature, most of which, however, are, from force of circumstances, necessarily excluded from these pages.

None of the *Salmonidæ* were found along our route on the eastern slope of the Rocky Mountains; but in most of the streams of Utah, more especially Black's Fork, near Fort Bridger, Weber River, and the Timpanagos, (flowing into Lake Utah through Provo Cañon,) the *Salmo virginalis*, a very handsome trout, was pl ntiful. In its habits and general appearance it much resembles the brook-trout of the Middle States, (*S. fontinalis.*) It is abundant in Black's For , from which, on the 25th of August, we caught half a dozen, and on the following day about forty, with the artificial fly, to which they rose exactly in the manner of their more eastern relatives, and greedily seized, like unsophisticated fish, as they were, scarcely learning caution or timidity until pricked once or twice by the alluring and deceitful bait. Probably but few artificial flies, if any, have ever before been cast on those waters. One specimen, about 10 inches in length, caught with a red-hackle, was selected for examination and description. In general outline it was, perhaps, slightly more stout than the brook-trout of New York, (*S. fontinalis.*) The curve from the nose to the anterior insertion of the dorsal fin was very regular. The anterior point of insertion of said fin was but slightly in front of a point at the middle of a line drawn from the tip of the nose to the insertion of the tail.

Colors.—Ground color of back, pale brown, tinged with red; spotted above the lateral line with small spots of black, which were but sparingly distributed anterior to the dorsal fin; a few spots of the same colors were also found on the opercula and on the top of the head. In shape, the spots anterior to the dorsal fin were nearly round and quite small; those in the vicinity of the same fin, but farther back, were stellate, but slightly larger, and those posterior to a vertical line drawn from the anus were much larger, more numerous, and quite irregular in form, somewhat resembling those of *S. stellatus*. Anterior to the anus there were scarcely any spots below the lateral line except near the head, where there were about half a dozen; posteriorly, however, they were equally numerous both below and above.

The general style of the spots, their size and distribution in individuals of this species, are well displayed in the gure given in Volume x, Plate lxxiii, Figs. 1–4. Indeed, in the markings, spots, &c., of this species, I noticed great uniformity in all the specimens observed. The color of the dorsal, adipose, and caudal fins was the same as that of the back, but thickly studded with oval and roundish spots of black. The prevailing reddish-brown color of the back extended to the nose, but was of a slightly different shade on the head. From the median line of the back it extended down the sides, filling up two-thirds of the space of the lateral line. The silvery-white of the belly was separated from the

prevailing color of the back by a faint golden band, of irregular width; [in some specimens this extends from the iris to the base of the tail.] The lateral line was distinct. Irides, golden bronze, with several roundish spots of black upon them of the size of a pin's head. The under fins were of a pale red, their external rays of a deeper color. Patches of bright vermilion, about one-eighth of an inch in width, were found extending back from the chin to a point opposite the middle of the opercula. The chin was white, like the belly. [The vermilion bands above spoken of exist normally in all the specimens seen of this species, and are present also in other species, for example, the *S. stellatus* of Oregon.] The tail was but slightly emarginate. Angle of mouth about opposite (below) the posterior border of the pupil.

The general hues of the Fort Bridger trout, when freshly taken, were silvery, glistening with bright reflections; the scales are somewhat larger than those of *S. fontinalis;* the point of greatest girth being reached by the tips of pectoral fins when stroked back. Upon inquiry at Fort Bridger, we learned that 17 or 18 inches might be considered the maximum size in those waters, and out of forty or fifty fish it is rare to find one over a foot in length.

The species in the Timpanagos River appeared, upon careful examination, to be identical with that of Black's Fork, but much larger. They retreat to the quiet and deep waters of Lake Utah, from whence they ascend the Timpanagos at certain seasons of the year. A friend there caught, in August, 1851, one trout which weighed some five or six pounds, (approximately,) and was 26 inches in length. They are said to grow occasionally to 30 inches in length, and are an active, fine fish, affording much sport to the fly-fisher, and a delicacy to the epicure.

About the 1st of September last, we caught three trout from the same stream. Two of these were of good size, weighing from $1\frac{3}{4}$ to $2\frac{1}{4}$ pounds, respectively. They rose freely to large, dark hackles, but refused gaudy or light-colored flies. Owing to poor flies, which had been in our possession for several years, the whipping of the hooks having shrunk so that they were easily pulled off, we caught but these three out of many fish that jumped at them. The stream was excellently adapted for casting the fly, and abounding in fish of fine size and quality, was fit to take position in an angler's paradise.

The trout of Weber River seemed to vary from those of Black's Fork, in having the lower fins much more tinged with yellow. The stomachs of all, when examined, were found to contain insects, such as wasps, beetles, ants, &c.

We are inclined to believe that the geographical range of the species extends to the west as far as Gravelly Ford, on the Humboldt. Specimens were examined which were caught at Deep Creek, one hundred and fifty miles west of Great Salt Lake. Approaching so nearly to the trout of all other places in general appearance, and trout-like habits so peculiar and unmistakable, we cannot refrain from again expressing entire want of faith in the so-called genus *Salar*.

29. SALMO LEWISI, Girard.

LEWIS'S TROUT; MISSOURI TROUT.

SYN.—*Salmo lewisi*, GRD., Pro. Acad. N. Sc., Phil., viii, 1856, p. 210;—IBID., P. R. R. Rep. Fishes, vol. x, p. 29;—SUCKLEY, P. R. R. Rep., vol. xii, p. 348, Pl. lxxi. [By mistake written ("*Salmo salar lewisi.*") The "*salar*" would have been stricken out had the author read the proof-sheets;] IBID., Nat. Hist. Wash. Terr. 348, pl.

Salar lewisi.—GIRARD, in both the works already quoted.

SP. CH.—Body somewhat thick; back well arched; head comparatively small, being contained a little more than five times in the total length of the fish. Ground color of the upper region olivaceous; of the lower, yellowish-white. The back, peduncle of tail, with the dorsal, adipose, and caudal fins, are profusely sprinkled with stellate and irregular black spots. The belly and lower fins are usually unspotted. Tail somewhat notched.

Young.—Resemble the young of *S. virginalis.*

DIAGNOSIS.—*Salmo lewisi*, Grd., is known from *S. virginalis*, Grd., by its smaller head; the greater dorsal arch; its more deeply-notched tail; that of *S. virginalis* in the adult being nearly even; by having the top of the head profusely spotted with black, and by having a different arrangement or plan of spot markings. The black spots are smaller, more numerous, more irregular in shape in this species than in *S. virginalis*, there being scarcely a well-rounded spot posterior to the middle of dorsal fin. The spots on the tail are more numerous, but not so large. The hues of this species are darker, and it is a stouter fish; its scales, also, are larger. For comparative measurements of the head and body see table.

The young of this species and the *S. virginalis* are very similar, and it is only by a comparison of adults that strong diagnostic marks present themselves. From *Salmo iridea*, Gibbons, this fish may be known by having larger scales; a much smaller head; dorsal outline more arched; head less spotted; fewer spots on body anterior to a line drawn from origin of dorsal to same of ventrals. These spots also are more symmetrically round. Those near the tail are very irregular and resemble in shape those of the *S. iridea.* The tail of this fish, although more cut out than that of *S. virginalis*, is much less forked than that of *S. iridea.* Adults of the latter, of one foot or more in length, show strongly-marked forked tails. A good example of this is shown in specimen 59, sent from Chico Creek, California. From other species of black-spotted trout the diagnosis can be made up by reference to their descriptions.

HAB.—Both slopes of the Rocky Mountains, north of the South Pass; head-waters of the Missouri, (Dr. Suckley, Dr. Cooper.) Southern tributaries of the Yellowstone; Black Hills, Nebraska, (Dr. Hayden.) Clarke's Fork of the Columbia, (Dr. Cooper, Mr. Gibbs, Dr. Kennerly.) Kootenay River, (Dr. Kennerly.) Specimens have been received from all

the above sources, and are now in the Smithsonian collection. Dr. Cooper obtained, in the autumn of 1860, a specimen of trout from the Bitter-Root River, Washington Territory, (west slope of the Rocky Mountains,) differing in no important character from two specimens of *S. lewisi* obtained by him at the Falls of the Missouri, in Nebraska. This gives the species a wide range—probably extending as far westward as the Great Falls on the Clarke, Spokane, and other rivers of the western slope. Another trout, got by Dr. Cooper from the Spokane River, above the falls, partakes partly of the characters of this species, and partly of those of the *S. iridea*, var. *stellatus*. It may be a hybrid between the two. It has no characters sufficiently distinct from either species to warrant the recognition of its title to a new name. Toward the Lewis trout the writer feels more than an ordinary interest, having probably the honor of catching the first of the species ever taken with the artificial fly. This was at a point a mile or so below the Great Falls of the Missouri, in September, 1853, after a horseback ride of thirty miles on purpose to procure specimens. Their existence had been indicated by Lewis and Clarke, who spoke of having caught *black*-speckled trout at the falls. I found them a lively, fine fish, jumping readily at the fly, and taking bait freely. Three-quarters of a pound appeared to be the average weight, but, doubtless, individuals of much larger size are found. Two of my specimens, taken in 1853, were sent to the Smithsonian, and were rendered typical of the species, as from them Dr. Girard based his original description. They still exist in the collection, numbered 520 in the museum catalogue of fishes.

30. SALMO BREVICAUDA, Suckley.

SHORT-TAILED TROUT.

SYN.—*Salmo brevicauda*, SUCKLEY, Notices of Certain New Species of North American Salmonidæ. New York, June, 1861.

SP. CH.—Body long and slender; its dorsal outline from a point opposite the posterior margin of the operculum being nearly straight. Scales large, quite thin, and glistening with metallic lustre; very loosely adherent. They encroach upon the tail for nearly a third of its length, thus giving it a short appearance. The peduncle of the tail is wide for the depth of the body, and the caudal itself is somewhat short and narrow. Head long, but not deep. Dorsal and caudal fins freely spotted with oval black spots. Body marked with small stellate and irregular dark spots, their number and size varying greatly in different individuals. There are usually two rows of teeth on the vomer. The head is contained nearly five times in the total length, which rarely exceeds eighteen or twenty inches. The tail appears shorter than it really is by reason of the great distance upon it that the scales extend.

DIAGNOSIS.—Upon a comparison of adults this species may be readily distinguished from *S. iridea* by its long, slender head and body, its appa-

rently short, narrow tail, and its thin silvery scales, so easily detached.

HAB.—Obtained from the waters of Puget Sound and the streams in that vicinity by Drs. Kennerly, Cooper, and Suckley.

This trout abounds in the fresh-water streams emptying into Puget Sound, and are not unfrequently caught in tide-water. It is known to the Nisquallies and Puyallups as the *kwusptl* or *skwuss-puttl.*

Mr. Gibbs obtained at Skagit River Rapids July 29, 1858, a small salmon or trout which the Indians said did not go to salt-water, called by them *tsee-tseh;* white beneath; back, grayish-olive. Its length does not exceed 10 inches.

31. SALMO GIBBSII, Suckley.

COLUMBIA SALMON TROUT; GIBBS' SALMON.

SYN.—*Fario tsuppitch*, GRD., in Proc. Acad. N. Sc., Phil., viii, p. 218, 1856;—GRD., Rep. on Fishes, U. S. P. R. R. Surveys, p. 318, 1858. [*Non salmo tsuppitch*, RICHARDSON.]

S. gibbsii, SUCKLEY, Annals N. Y. Lyceum, 1858;—IBID., Nat. Hist. Wash. Ter., p. 332;—IBID., P. R. R. Repts., xii, 332.

Black-spotted Salmon-trout, Lewis and Clarke;—*Shooshines* of the Walla-Walla.

Figures.—The typical specimen of the present species is figured as *F. tsuppitch*, in P. R. R. Rept. Fishes, vol. xii, Pl. lxix.

SP. CH.—Body elongated, compressed, fusiform in profile; dorsal outline but slightly arched; snout rounded, the jaws sub-equal; maxillary greatly curved, dilated posteriorly, and extending in a vertical line passing slightly behind the orbit; anterior margin of dorsal nearer the extremity of the snout than to the insertion of caudal fin; colors of the head and back, in the fresh specimen, rich, dark olive-green, profusely dotted with roundish black spots, the scales in certain lights showing bright silvery reflections; sides below the lateral line are usually unicolor, of a yellowish-white; inferior fins unspotted; tail and upper fins yellowish olive, profusely spotted with round and oval spots of black, each spot being from one to two lines in diameter, and completely isolated from the others, not confluent, as in some other species; caudal fin moderately lunated, not forked; head, small; teeth, small and very numerous, especially on the labials; length of the full grown adult rarely exceeds two feet.

HAB.—The Columbia River and its larger affluents. The species is not anadromous, but remains in fresh water throughout the year—so say the Indians.

In the typical specimen of this species (Smithson. Cat., 940) the length of the head, taking the extreme distance from the tip of the snout to the farther margin of the operculum, enters six times in the total length of the fish. Its length from snout to nape is contained nine times in the same. In its affinities this salmon appears in structure nearly related

to the anadromous, *S. truncatus*, and *S. gairdneri*, but its head, compared to the total length, is comparatively larger. It has, also, a persistently varied plan of coloration—its spot-markings being more numerous. The body, also, more compressed laterally.

No additional specimens of this fish have been obtained since the original description appeared. We may, therefore, be pardoned for reproducing a few remarks then made—more especially, perhaps, because it is desired to embody herein all the useful information concerning this group of fishes that will tend to assist the field naturalist, who necessarily can carry about with him but a limited library. "The typical specimen upon which the foregoing description is based is a single skin contained in the Smithsonian collection, Catalogue, No. 940, that of a female, obtained by the present describer at Fort Dallas, Oregon, April 5, 1855." The species is known to the Walla-Walla Indians as the *shooshines;* and to the Wascos by the name of *te-kwan-eek.*

Mr. Girard, taking the specimen for the *S. tsuppitch* of Richardson, figured and described it as belonging to that species. Upon his attention being called to several marked discrepancies between the account given by Sir John Richardson of the *S. tsuppitch* and certain characteristics of the specimen from Fort Dallas, he at once coincided with me in considering the two species distinct. According to Richardson, the *S. tsuppitch* has the dorsal, anal, and caudal fins destitute of spots and the tail forked. The present fish on the contrary, has the tail but moderately lunated at its extremity; and the dorsal fins and tail are profusely spotted with black. These prominent differences, besides many others less striking, have been deemed sufficient to settle the question of non-identity of the two species; and as no recorded description seems to refer to the present salmon, it is now presented as a new species, under the name *Salmo gibbsii*, in honor of my valued friend George Gibbs, esq., geologist to the Northwestern Boundary Commission, and for many years a resident of Washington Territory. To Mr. Gibbs, more than any other individual, am I indebted for rare specimens in all branches of natural history, and especially for information, aid, advice, and encouragement while endeavoring to elucidate the history of the Salmonidæ of the northwest coast.

This salmon is obtained, during the winter and early spring months, at Fort Dallas, Oregon. It is also found, during the summer, in the Yakima, John Day's, and other rivers emptying into the Columbia. In the fall of 1855 I obtained a fine specimen of a fish resembling this species from Boisé River, one of the tributaries of Lewis's Fork. Its flesh is good for the table, and the size renders it convenient for culinary purposes, as it rarely exceeds five or six pounds.

Most individuals have a broad reddish or blush along the sides, commencing at the middle of the opercula, and extending to near the base of the tail. This band is apparently subcutaneous, and may exist only in individuals not in prime condition.

Nathan Olney, esq., long a resident at the Dalles, Oregon, writes that this species does not go down to the sea, but that the Indians take it all the year round, except during the coldest weather in winter, and then, perhaps, because they do not fish for it. He adds that he has eaten them as late as December and as early as February, and thinks that if they do go to the sea, they "run" all the year.

32. SALMO SEBAGO, Girard.

THE SEBAGO TROUT.

SYN.—*Salmo sebago*, GRD. Proc. Acad. Sc. Phil., 1853, p. 380.
Salmo gloveri, GRD. Proc. Acad. Sc. Phil., vol. vii, p. 85, May, 1854. [Description of *S. gloveri* based on the young of *S. sebago*.]
Salmo gloveri, HARRIS, Proc. Phil. Acad. Sc., 1858, p. 136.

SP. CH.—[Based on three specimens in the Smithsonian collection.]

Male.—Head contained nearly four and a half times in the total length of the fish. Pectorals quite long, reaching to a line perpendicular to a point about half an inch anterior to first ray of the dorsal. Gape line of mouth much arched. Point of lower jaw armed with a conical flesh knob, projecting upward. Sides of the body, principally above the lateral line, covered profusely with large black spots, of roundish and irregular shapes, and occupying from three to five scales. The largest black spots on the fish are those on the operculum and pre-operculum. Lower fins and tail unspotted, and of a bright color, bordered with dark, (as seen in alcoholic specimens.) Free margin of tail handsomely crescentic. Scales very large and adherent. A row of teeth on the tongue, and another on the vomer.

Female.—(Specimen about 17 inches long.) Spotted much as on the male. Caudal more furcate. No fleshy projection from the chin.

Young, (*S. gloveri*, Grd).—According to Dr. Girard, have a few small, reddish orange dots in the middle of the black spots. These seem to be wanting in the adult. The color in the female is uniform silvery-gray, darker on the back and head. Subquadrangular or subcircular black spots are observed upon the sides of the head, behind the eyes, along the back and half of the flanks, also on the dorsal and caudal fins, to near the edge. In the male the same colors exist, but spread all over with a reddish tint, more intense on the flanks and beneath than on the head, back, and dorsal, and caudal fins where the red is sometimes but faintly indicated.

HAB.—Lakes in the "southern part of the State of Maine," Union River, Maine, Saint Croix River, Passamaquoddy Bay.

DIAGNOSIS.—From the young of *S. namaycush* and *S. siskowet*, by the presence of its black spots; also by the crescentic-shaped extremity of the tail—that of both of the other species being strongly furcate. This species, however, when not full grown, has a forked tail; that of the female is more so than that of the male. The young *S. sebago* may

be distinguished from the young of any other salmon and trout on the Atlantic slope, by its strongly-marked black spots and coarse scales. The adult male in the collection was 19 inches long. The young of this fish was described as a distinct species, by Mr. Girard, in 1854, and named the *Salmo gloveri.* Upon comparing the types of both, their manifest identity is so apparent, that I have not the least hesitation in making *S. gloveri* a mere synonym of *Salmo sebago*, Grd. Three specimens of the species are in the Smithsonian collection—male, female, and young.

Mr. Edward Harris, in a letter to the Phil. Acad. Sc., (accompanying specimens of what he called the *S. gloveri*,) read June 23, 1858, gives the following information concerning the species, of which he had taken specimens at the outlet of Grand Lake, on the western branch of Saint Croix River:

"These fish are taken also in moderate quantities lower down the stream. But on the waters below Lewey's Island, which are of a darker color and constantly filled with saw-dust from the mills, the fish lose their silvery brightness, and have the appearance of having been immersed in a yellowish dye; these fish, too, are always in a poor condition. * * * *

"It has heretofore been considered by those who are acquainted with this fish, that they were entirely confined to the waters of the Saint Croix, including its two branches and their lakes, in fact confined almost entirely to the lakes and their outlets; and it is only on this trip that I have heard of specimens having been taken as a variety in three small lakes which empty into the lower Saint Croix and into Passamaquoddy Bay. The fish described by Mr. Girard, as found in Union River, would have but a short distance farther to travel in the salt-water before entering that river. It is, therefore, pretty certain that they are, as far as yet known, confined to the waters of the Saint Croix, and streams of easy access therefrom by sea. They appear not to be known in New Brunswick, except in one of the small lakes alluded to, which empties its waters on that side of the river. Mr. Perley is said to be unacquainted with the fish, except from report. * * * *

"These fish, as taken, may be said to run from one to five pounds in weight, as it is very rare to take fish of a size intermediate between the small fish with the red spots, and those of the size of these specimens," * * * *

"As a game-fish, affording fine sport to the fly-fisher, I doubt whether it has its equal on this continent, with the exception of the true salmon. Its strength and agility are surprising; when hooked it will frequently make a succession of leaps, two or three feet clear of the water. It is most readily taken with the fly in more rapid waters above the dam, at the foot of Grand Lake, which has been made for the purpose of running logs. They are readily taken while the gates are up, but as soon as they are closed and the waters become still, they decline the fly, but

will still take the bait. At this time it is necessary to fish below the dam, where there is still a very rapid current, from leakage and overflow. The brook-trout, *S. fontinalis*, is taken in the same waters, and, in the stiller waters above, a large lake-trout, there called the *togue*, which differs from the *Salmo confinis* of the northern lakes, by having a more deeply forked tail like the *S. siskowet* of Lake Superior."

Mr. Harris there makes some interesting remarks on the peculiar deformed appearance which the jaws of certain salmons present during the spawning season.

33. SALMO KENNERLYI, Suckley.

KENNERLY'S TROUT; CHILOWEYUCK RED SALMON-TROUT.

SYN.—*Salmo kennerlyi*, SUCKLEY., Notices of Certain New Species of Salmonidæ. New York, June, 1861.

SP. CH.—*Male:* The head, measured from snout to nape, is contained about seven and a half times in the total length; when measured from the same point to extreme edge of operculum it is contained but four and three-quarter times. The point of greatest depth of body corresponds to a line drawn from the back downward, about midway between the tips of the adducted pectorals and the anterior insertion of the ventrals. The tips of the dorsal and ventrals when flattened backward reach the same imaginary vertical line. Adipose dorsal commences at a point nearly opposite the origin of the last ray of the anal—the tips of both fins extending backward equally far; tail strongly forked, its free margin somewhat waved. Snout somewhat turned up, the lower jaw projecting slightly beyond the upper. A single row of teeth along the anterior half of vomer. Teeth on the premaxillaries rather strong. Size of adult rarely exceeds 10 or 11 inches; body compressed laterally, its greatest depth contained four and a quarter times in total length. Dorsal outline strongly arched, from the nape, the ridge being somewhat sharp. Curve of belly from origin of ventral fin to that of the last ray of the anal very sharp; from thence to the caudal the upper and lower borders of the peduncle of the tail are almost straight and parallel. General color red, dingy along the back, paler on the sides, and fading to pure white on the belly. Small, irregular, black spots above the lateral line. Pectorals bluish, their tips slightly grayish. Dorsal and ventrals red. Tail slightly spotted.

Female: Jaws more equal. Snout curled up. Length about the same as that of male, but the depth of the body is not so great, neither is the sharp, bump-like ridge on the back so apparent.

Colors.—General color red, but slightly darker than the male. In other respects the sexes appear to agree.

DIAGNOSIS.—The *Salmo kennerlyi* can be readily recognized by its narrow, deep body, red colors; the back spotted with black, and the sharply forked tail.

HAB.—Chiloweyuck Lake, near the Fraser River, (Dr. Kennerly.) Nahoi-al-pit-kun R., (Mr. Gibbs.) This interesting species was first obtained at Chiloweyuck Lake, near the forty-ninth parallel, and but a short distance from Fraser River. It has seemed proper to name a fish so well marked and so distinct from any other known American species in honor of Dr. C. B. R. Kennerly, (its discoverer,) naturalist to the Northwest Boundary Commission, whose lamented death, while returning home after three years uninterruptedly spent in exploring the wilderness, has already been alluded to in the early part of this report. The full-sized figure in the plate was taken from a male specimen in good preservation, now in the Smithsonian collection. This has 25 rows of scales above the lateral line (counted just anterior to dorsal fin,) 24 below the line to middle of belly; 155 on the lateral line and its fin formula as follows: P. 17: D. 10: V. 11: A. 17: C. 21. In different individuals the branchiostegals vary from 12 to 15 on a side. One female had 12 on one side and 15 on the other. Mr. Gibbs's specimen from the west of the Cascade Mountains seems to differ only in size from those obtained at Chiloweyuck Lake. It is now in the Smithsonian collection, No. 2006 Museum Catalogue, fishes.

Dr. Kennerly, in his notes and journal, gives the following items of interest concerning it:

"*August* 16, 1859. *Chiloweyuck depot:* When we returned from our morning expedition, Lieutenant McKibben had been up to old Camp Chiloweyuck, and in the small stream near had seen vast numbers of a small species of red salmon, and had caught many. They doubtless ascend to get out of the way of the *chewagh*, who feed upon them. A *chewagh* weighing 9½ pounds, caught by the party to-day, had two of these small salmon whole in his stomach."

[NOTE.—Dr. K. must be mistaken about the cause of the appearance of this fish in such situations annually, as the *S. oquassa* and various other species have the same habit when about to spawn.—S.]

August 17, 1859. *Lake Chiloweyuck.*—To-day Captain Woodruff and myself took several men with us, and went after the small salmon mentioned by Lieutenant McKibben, yesterday. In a short time after reaching the small brook spoken of, we had rare sport, killing one hundred and eighty fish. Considering these sufficient for our present wants, we ceased and returned home. A Skopaalitch Indian calls the kind *tsi-mia*, and says they are common in Swheltscha and Pekosie Lakes, and that they never descend into smaller streams, and never go to the salt water. They are said to last but a short time, and disappear entirely after the arrival of the *kowhuts*. At another date he adds: "I believe this fish is peculiar to the Chiloweyuck Lake, where it makes its appearance, about the 10th of August, at the mouths of all the small streams emptying into the lake. They are then found in immense numbers; so numerous are they that they may be caught with the hand. They are followed by the *chewagh*, or large salmon-trout, who feed upon them. They try to escape

their enemies by crowding the most shallow brooks, where they are easily taken with a hand-net. The Indians here call them *tsi-mia*. About the 1st of September they disappear quite suddenly." Again he writes, September 1: "Have been fishing as usual, and with good success; caught a salmon-trout, or *chewagh*, *(S. campbelli,)* with hook and line, which weighed eight pounds. The little red salmon have nearly disappeared, and those left are turning white, undergoing the same change which takes place later in the season with the *kowhuts*." Kennerly, (in mss.)

34. SALMO WARRENI, Suckley.

WARREN'S TROUT.

SYN.—*Salmo warreni*, SUCKLEY. Notices of Certain New Species of N. A. Salmonidæ, New York, June, 1861.

Typical specimens 2070, 2073, in Smithsonian collection of fishes.

SP. CH.—[The largest specimens examined by the describer were not over 10 inches in length. They may have been immature individuals of a larger anadromous species, but were labeled "trout" by Dr. Kennerly.] Dorsal outline strongly arched; its convexity rising suddenly from the nape, and attaining its height at a point near a line drawn perpendicular to the lateral line and touching the tips of the pectorals when flattened backward along the sides. Head rather broad; muzzle somewhat conical; jaws equal and rounded. The eyes beneath plane of lateral line. Opercula and pre-opercula spotted with minute spots of black. Numerous stellate and irregular black spots, many of which are quite faint, as if obscured by the thickness of the overlying scales; belly white; back bluish or greenish; dorsal fins and tail spotted; scales small, (but much larger than in *S. fontinalis*,) compact and very adherent; when glistening in certain reflections, giving an enameled appearance to the fish. Tail forked.

DIAGNOSIS.—See text beyond.

HAB.—Waters of Fraser River, British Columbia, near Chiloweyuck depot. Dr. Kennerly.

Dr. Kennerly sent home six specimens of this salmon from Chiloweyuck depot. They are handsome and silvery, appearing as if fresh run from the sea.

The description was drawn from Dr. Kennerly's specimens already spoken of. The largest of these was about 9 or 10 inches long; the smallest not quite 6. In none were the dark bars of youth visible; so I have not been disposed to consider them the young of a larger species of anadromous salmon, although their silvery appearance would incline to that conclusion. They seemed to be more compressed laterally, and to have greater comparative depth than individuals of the species known as *S. iridea*, Gibbons; or of the *S. masoni*, Suckley. The thick glistening scales—obscuring to a certain extent the numerous black stellated spots beneath—serve as another point of difference between this fish and *S. iridea*, (*S. stellatus*, Grd.,) in which the scales seem thick,

and the black markings very apparent. This salmon is named in honor of W. J. Warren, esq., the Secretary of the Northwestern Boundary Commission, as a slight acknowledgment of the great and oft-repeated kindness with which he has facilitated the operations of the naturalists of the expedition.

Except the word "trout," on the invoice, Dr. K. has left nothing recorded upon the habits of this fish.

35. SALMO BAIRDII, Suckley.

BAIRD'S RIVER TROUT; RED-SPOTTED ROCKY MOUNTAIN TROUT.

SYN.—*Salmo bairdii*, SUCKLEY, Notices of New Species N. A. Salmonidæ, N. Y., June, 1861.

SP. CH.—Drawn from two skins of adults in the Smithsonian collection, one sent by Dr. Kennerly, the other supposed to have been sent by Lieutenant Mullan, U. S. A. Head contained about five times in total length; snout having a deep notch between the extremities of the premaxillaries, receiving a conical fleshy protuberance that projects upward from the chin. Teeth strong, hooked, and very uniform in size; two rows on the tongue; from two to four on the front of the vomer; none on its shaft. [In one of the specimens examined, a single accidental small tooth was found on the shaft of this bone; on the other, none.] Sides of the body beautifully spotted with rose-colored spots, of the size of small peas, of which there are numerous rows. Nostrils double. Tail broad, and but moderately lunated. Scales small. Anterior rays of the pectorals, ventrals, and anal, broad, and the skin upon them colored yellowish-red as in *S. fontinalis*. Attains the weight of ten or twelve pounds.

DIAGNOSIS.—This trout being a red-spotted fish, is not likely to be confounded with any species west of the Rocky Mountain divide, except the *S. campbelli* and *S. parkei*. From the former it may readily be distinguished by the great number, separation, and regular roundness of the red spots, and by lacking the cream-colored spots on the back, and also below the line of red spots which the *chewagh (S. campbelli)* has. The tit-like flesh protuberance at the chin and corresponding notch above are also wanting in the latter species. From *S. parkei*, it may be known by lacking the pale-green spots on the back, and by its smaller head.

HAB.—Clarke's Fork of the Columbia, and its tributaries. This beautiful species, a specimen of which Dr. Kennerly obtained in September, 1860, at Camp Kishenehn. It was caught in a mountain torrent, coming down from the main divide of the Rocky Mountains, and emptying into the Flathead River. At the same place several others were killed, apparently working up to spawn. Upon examination the fish soon proved to be undescribed. Its size and beauty induced the writer to name it after Spencer F. Baird, of the Smithsonian Institution.

It has many characters in common with the *S. fontinalis*, Mitchill, or common brook and pond trout of New York State. The color of the skin upon the broad anterior rays of the under fins, the red spots, small scales and general style, are very similar. But the different shape of the mouth, the notch between the intermaxillaries, the great size, the larger number of red spots, are sufficiently diagnostic.

The two specimens of this fine trout which we possess vary somewhat in their branchiostegals and fin-rays, as follows:

(Typical.) Br. 14: P. 13: D. 13: V. 10: A. 11: C.—Dr. Kennerly's specimen, No. 2010. Br. 13: P. 14: D. 11: V. 10: A. 10.—One supposed to be from Lieutenant Mullen, No. 2011.

36. SALMO PARKEI, Suckley.

PARKE'S RIVER TROUT.

SYN.—*Salmo parkei*, SUCKLEY, Notices of Certain New Species Salmonidæ, New York, June 15, 1861.

Green speckled-back trout. Aitkst, of the Kootenays.

SP. CH.—Head contained about four and a half times in the total length; its top flat; muzzle, pointed. Tail forked; unspotted. Back dark-green, spotted with spots of lighter green; sides spotted with red. Scales adherent and about the size of those of *S. bairdii.* A disposition toward the formation of a fleshy "tit" projecting upward at the point of lower jaws, with a corresponding notch between the premaxillaries. Superior maxillary reaches to a point considerably behind the eye. Branchiostegals 13–14. The anterior rays of the lower fins are covered with a differently-colored skin from that of the rest of the fin, as in *S. fontinalis* and *S. bairdii.* Two teeth on the outer extremity of the vomer, behind which from one to three on the shaft.

DIAGNOSIS.—From *S. campbelli* it differs in lacking the cream-colored or whitish spots along the back, by its large head and turned-up knob at the point of the jaw. From *S. bairdii* it may be recognized by its larger head, which is contained but four and a half times in the total length; that of *S. bairdii* being contained five times; also by its more deeply-notched tail, and by the presence of the pale greenish spots on the back.

HAB.—Kootenay River, Rocky Mountains.

"A specimen of a young male *aitskst* was taken April 6, 1860. Back lighter than olive-green; reflections silvery; beneath, white. Sides with light flesh-colored spots, nearly round; those on the back are of a very pale green. Length, 21 inches; head, 5; to end of lateral line, 18.50; to dorsal, 9.25; to ventral, 10.25; to anal, 14.50; to adipose, 15. Tail moderately lunated, having a spread of six inches. The body elongated and slender; head very long; mouth large, with thick "lips;" all the fins dark-colored. It is said to be found in the lakes of the Upper Columbia, Kootenay, and Clarke's Fork."—Gibbs.

37. SALMO OQUASSA, Girard.

BLUE-BACK LAKE-TROUT; THE OQUASSA TROUT.

SYN.—*Salmo oquassa*, GRD. Proc. Bost. Soc. Nat. Hist., vol. iv, p. 262. (Read before the society October 20, 1852.)

SP. CH.—[Condensed from Dr. Girard's description, and the examination of eight specimens.] Length (of full grown adult?) from 8 to 10 inches. Body subfusiform, slender, graceful. Head proportionally small, conical. Mouth smaller than in *S. fontinalis*, from which it also differs in the structure of the opercular apparatus. Fins placed in the same relative positions as the latter, but larger, excepting the adipose, which is considerably smaller. Margin of the caudal somewhat forked and undulated. Scales much like those of the brook-trout, but larger. Lateral line similar in both species.

Colors.—A bluish tint extends all along the back from the head to the tail, so that when seen from above the fish appears entirely blue. Sides and abdomen silvery-white in the female, and of a deep reddish-orange in the male, spotted in both sexes with the same hue as the abdomen. Dorsal and caudal fins brownish-blue, bordered with pale-orange in the male; the pectorals, ventrals, and anal of a fiery-orange, blackish-blue at their bases, and margined with white.

HAB.—Moosemeguntic Lake, Kenebago River, Lake Oquassa, Maine.

According to Dr. Girard this is a lake species, of great delicacy and beauty. It is found on Lake Moosemeguntic, making its appearance from the depths about October 10, and, coming near the shore, ascends the Kenebago River in shoals. Half a mile from its mouth the Kenebago receives the outlet of Lake Oquassa. The trout there leaves the Kenebago and enters Oquassa Lake, where its voyage comes to a close. After the middle of November it returns to Moosemeguntic, and is not again seen till the following year. It is known to the residents of that region as the *blue-back*.

Dr. Girard adds the following remark: "The flesh of the fish is highly flavored and more delicate than the brook-trouts in Europe and America. It resembles that of *S. umbla*, of the Swiss Lakes, both in the peculiarity of its habits and its delicacy. *Salmo umbla* is a lake-trout, an inhabitant of the deep, making its appearance near shores January and February to spawn, and never ascending the brooks or rivers, tributaries of the lakes.

DIAGNOSIS.—From *S. gloveri*, by lacking black spots; by its smaller scales. From *S. fontinalis*, or the common brook-trout, it can be distinguished by the uniform color of the back; its unspotted fins, (tail included;) slightly larger scales; small, conical head; slender body; small size of the light spots along the flanks, and by the colors, as given.

38. SALMO NAMAYCUSH, Pennant.

MACKINAW TROUT; GREAT LAKE TROUT.

SYN.—*The Namaycush salmon*, PENNANT, Arct. Zool. Suppl., ii. p. 139, 1792.
Salmo amethystus, MITCHILL, Journ. Acad. Sc. Phil., vol. i, p. 410; DEKAY, Nat. Hist. State of N. Y., Fishes, p. 240, Pl. lxxvi;—STORER, Synop. 1846, p. 193.
Salmo namaycush, RICH, F. B. A., vol. 3, p. 179, Pl. 79 and 85;—KIRTLAND, Report on the Zool. of Ohio, p. 195.—Boston Journ. N. Hist., 1842, iv, p. 25, Pl. 3, fig. 2;—AGASSIZ, L. Superior, p. 331, Bost. 1850.
Salar namaycush, VALENCIENNES, CUV. & VAL., H. N. Poissons, xxi, p. 348, 1848.

SP. CH.—[Drawn up from DeKay's description and the examination of specimens in the Smithsonian Institution collection.] Body robust; dorsal outline moderately arched. Lateral line nearly straight. Scales small, oval, adherent. Head one-fourth of total length. Nostrils double; contiguous muzzle somewhat pointed. Mouth large. Jaws strong? in the male, (when worn out;) the upper are longest, the lower having a conical point at their tip; jaws and tongue with a single row of teeth on each side; vomer with but a single row. Teeth strong, sharp, translucent; in the breeding season showing a beautiful amethystine color at their bases. Dorsal fin nearly in centre of fish; its height slightly longer than base.

Rays.—Br. 12: D. 12–14: P. 15: V. 9–10: A. 11–13. Pectorals low down, pointed. Caudal strongly forked. Length from 2 to 5 feet.

Colors.—Dark or dusky brownish-gray above: chin and under parts light-ash or cream-color. Back and sides specked with numerous irregularly-shaped spots of lighter gray, brown, or soiled-white. Lower fins slightly yellowish.

DIAGNOSIS.—From *S. siskowet*, by its pointed snout and chin; by its more deeply-forked tail; by the difference in the style or pattern of its markings; its larger size and larger head, which in this species is contained four times in the total length, while that of the siskowet nearly five. In the specimens examined by the writer, the teeth of the *namaycush* appear to rake backward more. From all other lake-trout it may be distinguished by its great size.

HAB.—Lake Huron, Lake Michigan, Lake Superior, and, according to Richardson, all the great lakes which lie between the United States and the Arctic Sea; but never found in tidal waters.

Only two specimens* of this fish are contained in the Smithsonian collection—both young, the largest about 20 inches long. These possessed a few teeth in a cluster at the anterior extremity of the vomer, and then a few scattered in a single row along its shaft, for half its length. But a single row of labial teeth. Sir John Richardson mentions a double

* Full collections at date of publication.

row of vomerine teeth, but may have been deceived by their alternate slanting toward opposite sides. Single rows of vomerine teeth will thus often mislead, by appearing as if double. In our humble opinion the character is of but little importance. We have dissected trout which were apparently identical in every other respect, taken from the same jar, and labeled from the same locality, some of which had single, some double, and others incomplete double rows.

According to Herbert, ("Frank Forrester,") from observations of his own in the region where they are found, out of hundreds of specimens which he saw, none weighed less than 17 or 18 pounds, and many as high as 45. Sir John Richardson quotes Dr. Mitchill as his authority, that one had been caught weighing as high as 120 pounds. It is rare, however, to find them weighing over 50. Herbert (*vide* Supplement Fish and Fishing) says, "The average of this fish is fully up to 20 pounds," and adds, "The flesh of this fish, as an article of food, is exceedingly bad; it is coarse, flabby, and at once rank and vapid, when fresh, if such a combination can be imagined." Again, he says, "When salted and smoked, or preserved in salt-pickle, it is somewhat better, though not at all equal to its sister fish the Siskowitz." He believes that neither fish can be taken with the fly or the spinning-minnow in trolling; and that, if ever taken in either of these modes, or with spoon or squid, it is contrary to their usual habit, and may be considered a freak of the fish, and one of so rare occurrence as to render it a very unprofitable attempt for the angler to endeavor to take them by any of these modes. This opinion was given after repeated inquiries "among Indians, hunters, and scientific anglers on the lake."

At Lake Superior they are taken in vast numbers through the ice. Strong lines some 50 feet in length are used, each having attached three or four baited hooks, so that it is not uncommon to capture two or more trout at a time. Suckers and other small fish form their ordinary food. They are said to be a very voracious fish, but not an active fish, unless hooked.

Herbert says: "A coarse, heavy, stiff rod; a long and powerful oiled hempen or flaxen line, on a winch, with a heavy sinker, a cod-hook baited with any kind of flesh, fish or fowl, is the most successful, if not the most orthodox or scientific mode of capturing him. His great size and immense strength alone give him value as a fish of game; but when hooked, he pulls strongly and fights hard, though he is a boring, deep fighter, and, I think, *never* leaps out of the water like the true salmon or the brook-trout."

In a discussion at a meeting of the Boston Society of Natural History, Professor Agassiz remarked that the color to which the *S. namaycush* owes its name of *S. amethystus* does not show itself distinctly while the fish is swimming, or when first caught, but only after being taken from the water, when the mucus on the surface begins to dry. The general color of this species varies with the ground on which it is caught. Those

found on a muddy bottom are generally grayish, while those from a gravelly bottom are of a reddish color, with much brighter fins. The sexes differ in shape, the male having a more pointed head than the female, although the jaws are of equal length. The ventral fins are placed very far back—a valuable specific mark in the *Salmonidæ*, a family in which it is very difficult on characteristic differences.

In answer to a question from Dr. Storer, Professor Agassiz replied that he did not notice the amethystine color in the mouth of this species.

39. SALMO CONFINIS, DeKay.

LAKE-TROUT.

SYN.—*Salmo confinis*, DEKAY. Nat. Hist. N. Y., p. 238, 1842.

SP. CH.—Colors blackish, with numerous gray spots. Body robust; comparatively short in proportion to its depth. Caudal fin, with sinuous margin. Length 2 to 4 feet. The body thicker and shorter than the common salmon. Head flattened. Snout produced, and, in old individuals, with a tubercular enlargement on the extremity of under jaw, which is the shortest, and received into a cavity in the upper. A row of teeth on the central furrow of the tongue. Attains a weight of 30 pounds.

HAB.—Lakes in Northern New York. Silver Lake, Pennsylvania. The foregoing description is condensed from Dr. DeKay's. He adds the colors of a freshly caught fish: "All the upper part of head and body, bluish-black. Sides of head and body, base of first dorsal, caudal, and anal fins with numerous rounded, crowded, irregular, gray spots." * * * Chin, brownish bronze. Irides, salmon-colored. Dr. DeKay's notes, as hinted at by Herbert, probably refer to two different species of fish—the present species, and perhaps *S. symmetrica*, Prescott. This will account for the discrepancy between his observations and the recorded evidence of others, as to size, &c. No specimens of *S. confinis* are in the Smithsonian collection.

Herbert's account of this lake-trout may possibly be applicable to the *S. symmetrica*, but, being quite interesting, is here introduced:

"Concerning no fish have I seen occasion so greatly to alter my expressed opinions, founded chiefly on the opinions of others, and, where original, formed from examination of fish taken in the waters of the Eastern States, and in Lakes George and Champlain, in none of which is it either a game-fish, or, in my opinion, a good fish.

"I still doubt greatly whether there be not two distinct species of lake-trout; one quite peculiar to the small lakes of New York. Certainly I never saw or tasted any lake-trout similar in appearance, or equal in taste and flavor, to those which I ate at Geneva, and which were subsequently sent down to me in ice, by my friend, Mr. Mandeville, of that city. The description of these fish exactly tallies with the account of the red-fleshed lake-trout of Hamilton County, where I have never fished,

being deterred therefrom by dread of that curse of the summer angler, the black-fly, which is to me especially venomous.

"A letter, which I insert below, from a capital angler, who has caught this fish in the far-famed Louis Lake, agrees exactly with the characteristics of the Seneca Lake trout, but not with his habits; as I have the best authority for stating that in Seneca Lake they are never taken either by the fly or by trolling; although in Crooked Lake, immediately adjoining it, they are constantly caught by trolling for them with shiners strung upon the hook, and drawn head foremost, with a hook, leaded to sink 20 or 30 feet.

"In Seneca Lake they are taken on set-lines, varying in depth from 25 to 400 feet; concerning which method, more under the head of lake-fishing.

"The following is an accurate description of one of the fish sent to me from Seneca Lake. It differs, as will be seen, in many respects, in structure, shape, and color, from the account quoted at page 117 from Dr. DeKay's Fauna of New York, almost widely enough, in my opinion, to justify its erection into a separate species.

"*Dental system.*—A double row of strong, hooked teeth, on the labials and palatines of the upper jaw. The vomer perfectly smooth and toothless. In the lower jaw, a single row of strong hooked teeth on the labials, and a double row of smaller size on the tongue.

"Branchiostegous rays, 11 on the right side, 13 on the left. Pectoral fin rays, 16; ventral, 10; anal, 12; dorsal, 13; caudal, 27.

"In all these respects it differs from De Kay's *Salmo confinis.* Whole length, 19½ inches. Head, 4 inches to the lower margin of the interoperculum. Eye, 1½ inches from tip of snout. Origin of the ventral fin, 9¼ inches; of the anal, 13; of first dorsal, 8½; of second dorsal, 14 from the tip of the snout. Depth of the fish at the origin of the first dorsal, 3⅗ inches; breadth of back, 2 inches. Curvature of the belly greater than that of the dorsal outline.

"Color of the head, dark bluish-black. Irides, silvery; gill-covers, silvery, with nacreous reflections. Back and sides, above the lateral line, beautiful, glossy, cerulean-blue, mottled with bright silvery spots of the size of large duck-shots; below the lateral line the silvery spots are larger and the ground lighter blue; belly, pure silver.

"Pectoral fins, pale yellowish-green; ventrals and anal greenish, very faintly tinged with red. First dorsal, greenish-transparent, veined with black; second dorsal, silvery-gray, slightly mottled; caudal, greenish-gray, mottled with black.

"A very beautifully-formed fish, more tapering than the *Namaycush* or *Siskowitz*, with the small head, and much both of the form and luster of the true sea-salmon. Flesh rich, orange-buff, very firm, highly-flavored, and delicate. This fish, and another, rather larger, but otherwise exactly agreeing with this, were eaten at my table by a party of six gentlemen, as good judges of good eating as any with whom I am ac-

quainted, and were unanimously pronounced better than brook-trout—better than true salmon—the finest fish in the world.

"The average weight is eight or ten pounds." This is an extract from the New York Fauna of Dr. DeKay. Now I venture to assert that Dr. DeKay never wet a line in the waters of Hamilton County, and that "the propensity to exaggeration in everything in relation to aquatic animals," induced his informant to make the above statement. I boldly assert that the average weight of lake-trout is not four pounds.

"An eight or ten pound fish is considered an unusually heavy fish. I will give you my experience. In May, 1848, I spent eleven days in Hamilton County, in company with a friend, and that friend an old Hamilton County troller. We faithfully fished in Lake Pleasant, Round Lake, and the far-famed Louis Lake. We killed about two hundred pounds weight of fish. I killed one of sixteen pounds, one of nine pounds and a quarter, and two of five pounds each. My friend did not kill a single fish heavier than three pounds and three-quarters; neither did I, save those just mentioned; and I would, and do say, that our fish did not average three pounds, the great majority being two-pounders. At the same time two friends fished Piseco Lake and Rackett Lake; the heaviest fish killed by them was eleven pounds; and I do not believe that they took another of greater weight than four pounds; at all events we beat them all to smash in weight and number. So much for the average weight. The wholesale assertion on your 118th page that they never rise to the fly should be qualified. It is not correct that they 'never rise to the fly.' They frequently do. The nine-pound-and-a-quarter lake-trout above referred to was killed by me with an artificial fly. The facts are these: On the 28th of May, 1848, I was fishing on Louis Lake. I was using a trolling-rod and a small trout-rod, casting with one and trolling with the other. Upon my trolling-leader I had two flies, and when my oarsman was in the act of pulling round a projecting elbow of wood, I reeled up to avoid contact with a fallen tree, and, just as my first fly trailed on the surface of the water, the fish broke or rather dashed at it. I struck him instantly, and away he went with so much velocity that I had hard work to keep my line from overrunning, not having a click-reel. I fortunately thumbed the reel, and passed my trout-rod to the oarsman, and then had fair play; and I assure you I never had hold of a fish of the same size that showed more game, power, or endurance. He never sulked for an instant; and the only difference which I could discover in his modes of action from a salmon was that, after being struck, he did not show himself or leap. Had I hooked this fish with my light rod I would not have killed him under an hour; and, indeed, as it was, he was not 'half gone' when Cowles, my guide, put the gaff into him. This fish rose in about 8 feet water, and took me twenty-five minutes to kill him. I never worked harder in my life to secure a fish, for you may imagine that I was anxious to secure a lake-trout hooked as I have described.

"On the same page you quote from Dr. DeKay that this trout has the 'coarseness of the halibut without its flavor,' and subsequently assert as your own opinion 'that this is the most worthless of all the non-migratory species.' I think that you are mistaken; my reasons, presently. On page 274 to 276, you also use the following expressions. 'These great, bad, and unsporting fish,' &c., 'with a bullet at the end of two hundred yards of line, run rapidly through the water.' 'He is very indifferent eating.' I disagree with you. 'Every man to his taste.' 'What's one man's meat is another man's poison.' I prefer a lake-trout to the best brook-trout—don't laugh! If it be 'very indifferent eating,' then I am easily pleased, and every person with whom I have spoken on the subject are no judges of fish-flesh."

40. SALMO SISCOWET, Agassiz.

THE SISCOWET, OR SISKAWITZ.

SYN.—*Salmo siscowet*, AGASSIZ, Lake Superior, p. 333, Bost., 1850. Pl. i, fig. 3.
Salmo siskawitz, HERBERT, Fish and Fishing, Suppl., p. 17.

SP. CH.—(Condensed from Agassiz's description.) Form stout, broad, thick. At the anterior ray of dorsal the height is equal to one-fifth the total length of the body. Middle part of the body rather cylindrical. Peduncle of tail dilated and subquadrangular. Head large, forming nearly one-fourth of the total length, excluding lobes of the caudal. Snout obtuse and rounded; several teeth on the anterior part of the vomer, then a row on the middle of its shaft. Two rows of very curved teeth on the tongue. Fins strong; dorsal higher than it is long. Scales small; larger on the lower region of body, behind the ventrals. According to Agassiz, the young are barred with dark, vertical patches, as is the case with the young of nearly all salmon and trout.

Br. 13: D. 12: A. 12–14: C. 6, 1, 9, 8, 1, 5: V. 9: P. 14.

Colors.—These vary according to their feeding-ground, and are brighter during the breeding season.

DIAGNOSIS.—From *S. namaycush* it can be recognized by its different opercular apparatus. (See Agassiz's description in his "Lake Superior," &c.) Also by the dorsal fin, which is higher than it is long, occupying the middle of the back. Caudal much less furcate. Muzzle more round. Ventral fins not placed so far posteriorly.

HAB.—Lake Superior, especially along the north shore.

Professor Agassiz says that the siscowet is a rich, highly-flavored fish, but too fat. This renders its preservation in alcohol very difficult. He obtained his specimens from Michipicoten, the same place from whence Mr. George Barnston sent the only specimens that are contained in the Smithsonian collection—four in number. The heads of these fish are smaller than those described by Professor Agassiz, but in other respects they agree with his description.

Mr. Barnston, in a letter, speaks of the existence there of another kind

of lake-trout, differing from this species, which he calls the "*bear-trout.*" He says that the distinctness of the species is recognized by the Indians, and that they spawn at a different season. He mentions having sent a specimen. After careful examination I can detect no differences of value between the different individuals sent by him.

Herbert, in his "Supplement," affirms that, as a sporting fish, the "*siskawitz*" is of no value; but, in the following quotation which I have made, acknowledges its high gastronomic excellence:

"This fish, like the former species, came frequently under my eye during my late northern tour; and I rejoice in the possession of a barrel of him in his pickled state, which I procured at the Sault Ste. Marie, on the strength of which I can recommend him to all lovers of good eating as the very best salt-fish that exists in the world. He is so fat and rich that when eaten fresh he is insufferably rank and oily; but when salted and broiled, after being steeped for forty-eight hours in cold water, he is not surpassed or equaled by any fish with which I am acquainted. Since my return he has been tasted by very many gentleman of my acquaintance, and by no one of them has he been pronounced anything less than superlative. His habits closely resemble those of the *namaycush*, and, like him, I cannot learn that he ever takes the fly or is ever taken by trolling. I do not, however, believe that either of these methods are often resorted to for his capture, although there are many scientific fly-fishers about the Sau and the brook-trout of those waters are principally taken with large and gaudy lake-flies. The average weight of the *siskawitz* does not exceed four or five pounds, though he is taken up to seventeen. His excellence is so perfectly understood and acknowledged in the lake-country that he fetches double the price per barrel of his coarser big brother, the *namaycush*; and he is so greedily sought for there that it is difficult to procure him, even at Detroit, and almost impossible at Buffalo."

41. SALMO SYMMETRICA, Prescott.

WINNIPISEOGEE TROUT.

SYN.—*Salmo symmetrica*, PRESCOTT, Silliman's Jour., 2d series, xi, p. 340, May 1851. Read before Asso. of Am. Geologists and Naturalists, Boston, Sept. 1847.

SP. CH.—(Condensed from Dr. Prescott's description and from the examination of specimens.) Form, slender, symmetrical; a single row of teeth on the vomer and palatines. Head contained about four and a half times in the total length; position of dorsal fin considerably anterior to the middle point of total length; tip of anal fin extends some distance behind tip of adipose dorsal. Scales small. Lateral line waving for the first inch or inch and a half, commencing a little below the superior posterior angle of the operculum and gently descending for a short distance, and then ascending as much, when it proceeds in a straight line to the middle of the tail. Head slightly flattened between

the eyes. Jaws nearly equal and pointed; the extremity of the lower received into a cavity above. Jaws, tongue, palatine, and pharyngeals armed with a single row of small, pointed, recurved teeth. Teeth of lower jaw larger and less numerous than of upper. Pupils, black; irides golden. Tail deeply forked. (Prescott.) Integument covering the under surface of the arms of the lower maxillaries is pierced with several small pores or holes.

DIAGNOSIS.—The only species which this fish is likely to be confounded with are *S. confinis*, DeKay, and the young of *S. namaycush*, Penn. It will be recognized by its very slender form, by lacking teeth on the central furrow of the tongue, and those of other parts of the mouth being disposed in single rows; by the more anterior position of the dorsal fin. Scales very small, but much larger than in *S. fontinalis*.

HAB.—Winnipiseogee Lake. ? Lake George.

Dr. Prescott gives the following description of a specimen 20 inches long; weight 30 ounces:

"Distance from the extremity of the jaws to the eye, 1⅕ inches; to the dorsal fin, 9 inches; to second dorsal, 14½; to ventrals, 9½ inches." * * * "Length of base of dorsal fin equal to one-tenth of the length of the fish; height of the same, (longest rays,) 2½ inches." * * * "Caudal fin deeply forked; the distance between extremities of bifurcation being 4½ inches, or equal to length of the head."

Colors.—In a foot-note Dr. Prescott says: "It is worthy of remark that the color of this fish, in common with many others, is very much influenced by the nature of the bottom upon which it feeds, being uniformly much darker when frequenting muddy than gravelly bottoms, or rapid streams. The color varies with age, and in many instances there is a marked difference between the color of the male and the female."

The colors of the specimen whose measurements are above given were as follows: "Light to dark brown on the back and upper part of the head; sides dark-gray above lateral line, lighter below, in some approaching to light salmon; lower jaw, chin, and abdomen white, mottled with fuliginous; pectorals and ventrals gray, their anterior part being shaded faintly with pink. Dorsal and caudal fins dark-gray. The whole fish, including the dorsal and caudal fins, thickly sprinkled with small circular spots of a drab color on the sides, olive on the back, approaching to light salmon below. These spots become elongated and variously curved on the top of the head, and of an olive color, giving to the part a marbled appearance." He adds: "This trout during winter is taken in great abundance by the hook, through holes cut in the ice, but not in such numbers as formerly. They are not unfrequently taken weighing 12 to 15 pounds. The largest reported to have been taken weighed 25 pounds. By most persons it is highly esteemed, and it is generally considered an excellent fish for the table."

Two specimens from Lake Winnipiseogee are in the Smithsonian collection. From a careful examination we are led to believe that the species

is distinct from any described previous to Dr. Prescott's paper. There is also in the Smithsonian collection a jar, numbered 3588, on the fish catalogue, a lot of trout from what is supposed to be Lake George, New York, but the locality is somewhat uncertain, owing to the obliteration of the writing on the first label. They, however, resemble the *S. symmetrica* so closely that I have had no hesitation in labeling them as such. The light markings, common to the fish when fresh caught, apparently fade out in alcohol.

NOTE.—Since writing the foregoing, a reference to *S. hoodii* has caused regret that no indisputable specimens of that fish could be obtained for comparison.

42. SALMO HOODII, Richardson.

HOOD'S SALMON; THE MASAMACUSH.

SYN.—*Salmo hoodii*, RICH. F. B. A. iii, p. 173; Pl. 82, fig. 2; Pl. 83, fig. 2; Pl. 87, fig. 1; DEKAY'S Report, p. 242; STORER'S Synop.
? *Salmo carpio*, FAB., (RICH.) A Greenland species.

SP. CH.—[Condensed from Sir John Richardson's original description.] Head a little more than one-sixth of total length. Lower jaw, when the mouth is closed, projects beyond the upper by the depth of the chin; its length applied to upper surface of head, passes about a quarter of an inch beyond the nape, in a fish about 18 or 20 inches long. A single row of teeth on each side of the tongue, a few scattered teeth also about its middle. Operculum half as wide as high. Caudal (in the adult) even at the end. Average weight of a full-grown adult, 8 pounds.

Colors.—[Taken from a female 21 inches long; season, August.] Back and sides intermediate between olive-green and clove-brown, studded with yellowish gray spots, as big as a pea, a few of which are on the gill covers. Belly and under-jaw white, the latter thinly dotted with bluish-gray. Dorsal and upper lobe of caudal marked with smaller spots.

HAB.—Fresh-water lakes on the Atlantic slope of America, from Canada northward.

43. SALMO NEWBERRYI, Girard.

SYN.—*Fario gairdneri*, GRD. Proc. Phil. Acad. Sc., viii, 1856, p. 219; GRD. Pacific R. R. Repts., x, p. 313 [not *Salmo gairdneri*, RICH.]
Salmo newberryi, GRD. Proc. A. N. Phil., p. 225, 1858, (referring to Plate lxxi, figs. 1–4. P. R. R. Reports, vol. x.

SP. CH.—[Copied from Dr. Girard's report, P. R. R. Repts., vol. x, p. 313.] "Body subfusiform in profile, very compressed head, comprised four times in the length, the caudal fin excluded. Upper jaw longest; maxillary curved, extending to a vertical line intersecting the posterior rim of the orbit. Anterior margin of dorsal equidistant between the extremity of the snout and the base of the caudal. Caudal fin furcate.

Back, silvery-gray; sides silvery, and belly yellowish-white. Body obsoletely spotted with black; similar black spots on the dorsal and caudal fins."

The figure given by Dr. Girard was taken from a single specimen contained in the Smithsonian museum, and said to be of the size of life. The specimen has disappeared from the collection, so that we are unable to judge whether it is the young of an anadromous salmon, or, what I suspect, simply a variety of the *Salmo iridea*, Gibbons. It was procured by Dr. Newberry from the Klamath River.

IV.—THE SALMON OF THE DANUBE, OR THE HUCHO, (SALMO HUCHO,) AND ITS INTRODUCTION INTO AMERICAN WATERS.

By Rudolph Hessel.

[Note.—The following communication upon the *Hucho* was prepared by Mr. Rudolph Hessel, at my request, and embodies some facts of much interest in reference to this fish. The propriety of introducing so voracious a species, and one that remains and feeds entirely in fresh waters, where the sea-salmon occurs, or can be introduced, may perhaps be questioned, but whether it might not be planted to advantage in the more southern waters of the United States, or even in the Mississippi Biver, is well worthy of consideration.

S. F. BAIRD.

The Danube salmon differs from the other *Salmonidæ* by its more cylindrical and elongated body. The back is of a dark brownish-green; the belly, silver-white, and on its sides are black, round, and half-moon-shaped spots, which are more crowded along the upper part of the back: in this exhibiting a resemblance in marking to the sea-trout.

With increasing age (fish of 12 to 20 pounds and more) the sides exhibit a reddish tint, which becomes of a beautiful rose-color during the breeding season, and gives rise in some places to the name of "red-fish," not to be mistaken, however, for the "*Röthel*," (*Salmo umbla*, or *salvelinus*.)

The Danube salmon surpasses all other *Salmonidæ* in size, and attains a weight of 40 to 60 and 100 pounds. In rare cases, specimens even of 120 pounds have been caught. Its flesh is almost like that of the salmon of the Rhine in quality, but is white, while that of all the other German *Salmonidæ* is red.

A special peculiarity of this fish is its limited geographical distribution, occurring only in the streams emptying into the Black Sea, especially the Danube and its tributaries. When young (weighing from 12 to 18 pounds) it has its abode in the deep, rapid, mountain branches of the Danube, and afterward descends into the river itself, in the lower portion of which, near Galacz, Semlin, &c., it is found of fully developed size. The rivers Drave, Save, and Theiss, the principal southern tributaries of the Danube, also abound in full-grown fish. It is also frequently caught in the northwesterly tributaries, above Vienna—the Inn, Lech, Isar, Salrach, Altmühl, Regen, Iller, and even the small Brenz; indeed, generally, everywhere in the Upper Danube of Würtemberg. Except as indicated

above it is to be met with nowhere else in Europe. It also occurs in the Black Sea, but only near its shores, and also in the Dnieper, which discharges its water into the Black Sea near Odessa; likewise in the Volga and Ural Rivers of the Caspian Sea.

The Danube salmon has not the peculiar habit of migration from the sea of the true salmon (*Salmo salar*) though it also ascends the rivers to spawn, like most other *Salmonidæ*. Differing from the other European salmon, however, which breed in autumn or winter, it deposits its eggs in March, April, and May, the female making large cavities in the middle of the river for the purpose, called by the fishermen of the Danube '*bruch*,' (break.) Accompanied by several males the female fish deposits its eggs at the bottom of these excavations, and while thus engaged are easily caught with the 'trident,' or fish-spear, and even after one of the males has been taken out the others leave the place only for a short while to return and meet the same fate. Many fish are thus captured during the breeding season, greatly to the injury of the fisheries; and although laws prohibiting this mode of fishing during the breeding season have been enacted in all the littoral states of the Danube they are mostly evaded.

The eggs of the Danube salmon have a diameter of about .20 of an inch, and their yolk is not a connected mass, as in the eggs of the other *Salmonidæ*, but is distributed in oily drops upon the entire inner surface. A period of forty to fifty days in cold weather, even more, is necessary for hatching. The eggs are rather sensitive and suffer greatly from the rapacity of the grayling, *Thymallus vexillifer* Agassiz, which exist in great numbers in the tributaries of the Danube. They follow the female *hucho* in shoals, and voraciously consume the eggs. Hence this beautiful fish is never so abundant as is the *Salmo salar* in the Rhine, where the *Thymallus* is far less numerous than in the Danube. In addition to this, the season for depositing their eggs is far more favorable to the *S. salar*, since then the *Thymallus* are full of milt and eggs and less hungry than at spring-time, when they have just done spawning. The young fishes lose their yolk-bag after ten to eighteen days. They have a length of .80 of an inch when hatched, 6 to 6.30 inches when six months old, and 24 to 32 inches after two years. This rate of growth is quite favorable, when compared with that of the European brook-trout, but is less than with the other *Salmonidæ*, which, migrating to the sea, there find richer nourishment than the *hucho*, which generally remains in the river. Since the *hucho* does not enter the sea, for this reason it appears especially adapted to the large lakes of America, as well as to the Mississippi and its tributaries.

In its third year the *Salmo hucho* attains its maturity for propagation. Before that period it prefers to remain in the small rivulets; but when sufficiently grown prefers the most rapid places of the larger tributaries, where rocks, trunks of trees, &c., offer shelter. Like the *S. salar*, it ascends obstructions several feet in height, sometimes six to eight. Like the other large *Salmonidæ* it is a rapacious fish, neither more nor

less so than its congeners of equal size, but is, I believe, decidedly surpassed in voracity by *Silurus glanis*, the sheat-fish, a kind of cat-fish, and the pike, *Esox lucius*. The daily consumption of food of the last-mentioned species, according to my own observations, amounts to one-third of its own weight. The *S. hucho* has a bad name for voracity, because it is not at all dainty; it preys on its own kind, catches frogs and water-fowl, and even does not refuse water-rats. But, after all, it consumes, in proportion to its size, far less than the smallest trout; and the most reliable fishermen of the Danube agree with me in the opinion that it is not as bad as reputed. True, it shows great energy in pursuit of food, but this occurs principally in winter-time when most of the other fishes remain in their hiding-places and the river is covered with ice. In such cases it frequently jumps high up the banks, where it is easily killed.

I have often examined the stomachs of these fish of different sizes, and mostly found white-fish and frogs, sometimes salamanders (*Triton cristatus*,) and once even a ring-snake (*Tropidonotus natrix*).

I believe that in the sluggish southern rivers of North America the numerous salamanders would serve as food, as the *hucho* loves to hunt in bends of the river overgrown with cane, and shows great skill in catching his prey.

Several years ago some ichthyologist maintained that the *hucho* is subject to a peculiar disease of the skin, of which he gave a description. This is, however, a mistake, as I have ascertained by consulting many of the fishermen of the Danube, and to my certain knowledge may occur in any fish very frequently on the carp. It is a spongy excrescence originating where the skin had been injured or the scales rubbed off, and of fungus origin, the same mould, viz, *Leptomitris clavatus*, which sometimes covers the eggs in breeding establishments, especially in winter-time, especially when dead animal matter had been allowed to contaminate the water.

The mode of catching the *hucho* differs greatly along the extended banks of the Danube, and is influenced by the situation, depth, &c., of the river. In summer-time they are taken in nets, and smaller ones, up to 6 pounds, with the fly, which, however, is refused by the older fish. From October to their spawning-time, even during the coldest winter, and under the ice, they are also to be taken with minnow-bait on ground-hooks. No other fish of the Danube besides the pike will take the hook.

No fish of the salmon tribe, the true salmon, *Salmo salar*, not excepted, affords more sport to the angler than the *hucho*, especially before the river becomes covered with ice, or when it breaks up in spring, and whether small or large, from 1 pound up to 60, none takes the hook at this season more readily. In rapids or other places, provided they are free from ice, the fishing is always successful. I have frequently practiced this mode of fishing in the Danube, from Linz to Galacz, and in its tribu-

taries, Lech, Inn, Salzach, Theiss, Drave, Save, Marosz, even in the severe winter of 1852, and always to my satisfaction.

I am entirely satisfied that the *S. hucho* will be admirably adapted for the Mississippi River and its numerous tributaries. The large, deep indentations, overgrown with cane, as well as the numerous rapid mountain affluents, offer favorable abodes. The large lakes of the United States appear also to be equally appropriate for this fish. This, of course, is nothing more than my individual opinion, but that its acclimatation is possible is beyond doubt.

For the introduction of this fish two ways seem to be indicated: 1, the direct importation of a number of live fishes, about one year old, to be nursed in a suitable small lake until mature for propagation; or, 2, the importation of a large number of impregnated eggs to be artificially hatched. The former has great difficulties, as the *hucho*, like all salmon, constantly requires fresh water; still I should be willing to try it with about twenty-five to fifty specimens of the age of six to twelve months. It would, however, take almost three years before the fishes would be fit for propagation, and this is a great loss of time. The latter method offers no less difficulties, viz, the collection and transportation of the eggs, which are very sensitive, especially as the temperature of the season is rapidly increasing, when they are spawning. It is scarcely credible that their artificial impregnation is entirely unknown to the fishermen of the Danube, although they believe it possible with the trout.

It would therefore be necessary to engage the most intelligent of the fishermen; to instruct them, and, if they are willing to do the collecting, to assign a centrally-situated place, where the hatching can be carried to the first stage, viz, the development of the eyes. Immediately after the impregnation eggs would not endure transportation for more than two days.

I have consulted several fishermen of the Danube, in person as well as by letter, and believe I could obtain 600,000 to 700,000 eggs in the first year. This is a considerable quantity, under these circumstances. The eggs are very sensitive, and will need to be managed by an expert; as the fishermen are entirely ignorant, and even require to be informed the mode of packing, &c. Hüningen, in 1872, secured 10,000 eggs, for which a man was sent to the Bavarian Danube. Mr. Schuster also received about 2,000, which were hatched. Those at Hüningen perished. It was the first time Messrs. Schuster and Haack had tried the hatching of *hucho*. In Germany preference is given to the salmon of the Rhine over the *hucho*, and even over the salmon of the Elbe, though the latter is the same fish. I believe, however, that the *hucho* will improve in the Rhine, as does every other fish, though it is already a splendid table-fish and desirable not alone on account of size. In reference to the difficulties of transportation, I need not direct your attention to the fact that they become so much greater in a journey to America. But as I reported in one of my last letters to Washington, I hope to meet all

these difficulties by the adoption of a little apparatus, by means of which I may safely carry 400,000 to 500,000 eggs. I think I have overcome the difficulties of construction. Ice for cooling, as you suggested, will be applied without allowing direct contact of the eggs with the melting water. Of this apparatus I hope to exhibit drawings and models in America when I see you. In conclusion, I have to say, that it will be necessary for the fishermen to ask permission for the collection of eggs, which, however, could be readily obtained.

I believe that now I have told you all, the good and bad, of this fish; it is, however, far from my purpose to unconditionally recommend its introduction into your country. I believe the *Salmo salar* ought to be tried in the Mississippi at the same time, as the Gulf of Mexico would afford rich feeding-ground. The Ohio and Missouri, with their many tributaries, may also be found suitable.

P. S.—Of late years there is, everywhere in Europe, manifested the desire to destroy the pike in lakes and ponds. Although our laws are quite stringent and are strictly executed, the catching of *Esox* is allowed even in spawning-time, as rational fish-breeding has proved them injurious. *Salmo hucho* and the other *Salmonidæ* are protected by law during the spawning-season.

I consider the *omul* or *Salmo omul* of Baikal Lake as one of the most excellent of the *Salmonidæ*. It is, however, at present scarcely to be had in Europe. According to my information, it surpasses the Salmon of the Rhine in quality, and is extremely prolific. About 20,000 hundred-weight are said to be caught in the lake, and preserved by smoking, every year. *Salmo omul*, as far as I know, has never been described satisfactorily in any work of natural history.

Very respectfully, yours,

RUDOLPH HESSEL.

Professor S. F. BAIRD,
United States Commissioner.

V.—IMPROVEMENT IN THE SALMON FISHERIES OF SWEDEN.

EXTRACT FROM THE REPORT OF THE ROYAL SWEDISH INTENDANT OF FISHERIES. 1868.

In 1855, the state of the fisheries in Norway was taken into consideration, and establishments for fish-breeding were introduced. At the same time protecting laws were enacted, which, in 1863 and 1865, were further amended, in accordance with the experience acquired. The most important rivers and lakes were subdivided into fishery districts, and supervisors were appointed to insure the observation of the laws, one-half of their salaries being paid by the government, the other by the owners of the fisheries. By these means the same practical advantages have been obtained as in England. As early as 1865 the inspector of fisheries was able to present testimonials from Dramself, Langenself, and Mandalself in proof that the protecting laws and the fish-breeding establishments thus introduced had steadily increased the yield of the fisheries during the last five years; in 1868, testimonials of twelve more rivers and lakes were added. With every year the satisfaction with these regulations becomes greater and greater in Norway. If we compare the results obtained in France, where they endeavored to improve the fresh-water fisheries *solely* by artificial breeding, we find them quite different. From 1853 to 1865 great sums of money were expended; the central fish-breeding institution of the state at Hüningen, which in 1862 had already cost 600,000 francs, had distributed nearly thirty millions of young salmonidæ every year, and still the fresh-water fisheries were found in the same bad condition as before. It is maintained by some that by the establishment at Hüningen the stock of fish had not augmented in the Seine, the Loire, the Garonne, and the Rhine by more than a very few trout and other *Salmonidæ*. Consequently finding that breeding alone would not produce the desired improvement in fresh-water fisheries, it was decided to be necessary, even in 1865, to enact protecting laws in order to get a firmer basis and better results for the work done.

From this brief statement it is evident that, from fish-breeding establishments only and solely, a considerable increase of fish is not to be expected, and, at the same time, that fish-breeding, in connection with suitable protection and rational management, will produce equally favorable results as is the case with other industrial enterprises.

It will also be seen how important a position protection and proper system occupy in the several transactions, in co-operation producing the above-mentioned favorable results. Hence the conclusion is justified

that protection and rational management of fisheries will give satisfactory results, even without the labor and expense of artificial breeding; nevertheless, that artificial breeding, without any doubt, acts a very important part in promoting the improvement of fisheries. For everywhere in nature we find that in some years or seasons the propagation of certain plants or animals suffers from unfavorable accidental circumstances. The same is the case with the fishes; and it may be, at least in part, counteracted by artificial breeding-establishments, which offer some protection against destructive changes in temperature, against floods of muddy water, or the attacks of numberless enemies.

Furthermore, in many even extensive systems of waters, some species of valuable fish have disappeared almost entirely, and it would require many years to increase the stock from the few individuals left. In such cases artificial propagation will offer effective and useful means for obtaining more rapid and certain results from protection, &c., which will be always required for improving extensive fisheries.

The great importance of artificial fish-breeding undoubtedly consists in the facility of introducing new varieties, by means of artificial impregnation, transportation, and hatching of the eggs. It is, of course, necessary to success to select the water, nourishment, location, &c., so as to be adapted to the habits of the species to be transplanted. Norway, and more recently Sweden also, have thus obtained the most valuable results. In Norway salmon are now frequently caught, where they were introduced only a few years ago. *Schnepel* (*Coregonas oxyrhynchus*) of 6 pounds' weight are found in Jemtland, and red salmon *Salmo alpinus* of 13 pounds in the North Sea, Black Sea, Orange, where before 1860–'64 (*i. e.*, the time of their introduction) none were to be met with.

In the river between the Lakes Hunn and Tisnaren great numbers of young salmon are now to be seen, having been transplanted in 1866 and 1867. The interest in raising valuable fish is constantly increasing. Oestanbäck and Gullspang cannot supply the yearly demand of eggs. Three hundred and twenty-five thousand *schnepel* eggs were sent from Gullspang in 1868. At present five new fish-breeding establishments are about to be started.

As a lucky and, in its kind, peculiar transfer may here be mentioned, that *smelt* were, in 1866 and 1867, introduced into the Lake Walloxen, near Stockholm, and in the succeeding spring were found to have greatly increased in number. Since the occurrence of *smelt* in any water is so far of importance as it shows the water adapted for breeding *Salmonidæ*, &c., this experience of the Swedish fish-propagating establishment is in many respects remarkable.

VI.—REPORT OF OPERATIONS DURING 1872 AT THE UNITED STATES SALMON-HATCHING ESTABLISHMENT ON THE M'CLOUD RIVER, AND ON THE CALIFORNIA SALMONIDÆ GENERALLY; WITH A LIST OF SPECIMENS COLLECTED.

By Livingston Stone.

A—INTRODUCTORY REMARKS.

1.—THE SALMON-HATCHING ESTABLISHMENT ON THE M'CLOUD RIVER.

San Francisco, California, *December* 9, 1872.

Sir: I beg leave to report as follows:

In pursuance of your instructions received in July last, to proceed without delay to the Pacific coast, and make arrangements for obtaining a supply of salmon eggs, I left Boston on the 1st day of August, for San Francisco, with this object. As I was directed in your subsequent letters to obtain, if possible, the eggs of the Sacramento River salmon, I set myself at work at once to ascertain the time and place of the spawning of these fish, but, singular as it seems, I could find no one in San Francisco who was able to say either where or when the salmon of the Sacramento spawned. Those best informed in regard to fishing matters, advised me to locate at Rio Vista, the chief salmon-fishing ground of the Sacramento. This seemed practicable at first, but, on examination, the water at Rio Vista was found to be wholly unsuitable, and this place was given up. Fortunately, a short time after, I was introduced, through the kindness of Hon. B. B. Redding, a member of the board of California commissioners of fisheries, to Mr. Montague, the chief engineer of the Pacific Railroad, who showed me the Pacific Railroad surveys of the upper waters of the Sacramento, and pointed out a place on the map, near the junction of the McCloud and Pit Rivers, where he assured me he had seen Indians spearing salmon in the fall on their spawning-beds. This point is one hundred and eighty-five miles north of Sacramento City. Following this clew, I proceeded to Red Bluff, the northernmost railway station of the California and Oregon Railroad, situated fifty miles from the McCloud River. From inquiries made here, I became so well convinced that the salmon were then spawning on the McCloud River, that as soon as supplies and men could be got ready I took the California and Oregon stage for Pit River ferry, two miles from the mouth of the McCloud. We arrived here at daylight on the 30th of August. Leaving the stage at this point we followed up the left bank of Pit River on foot, to the mouth of the McCloud, and continued thence up the McCloud River. At a distance of about two miles above the mouth of the river, we came upon several camps of Indians with hundreds of freshly caught salmon drying on the bushes. Salmon could also be seen in the river in such

numbers that we counted sixty in one spot, as we stood at the waters' edge. It was evident that this was the place to get the breeding fish, and the next thing was to find water to mature the eggs for shipment. This was not so easy a task as finding the salmon, but we at last discovered a spring stream, flowing a thousand gallons an hour, which I decided to use, this season at least, and on the morning of September 1, 1872, the hatching-works of the first salmon-breeding station of the United States were located on this stream. The location is about three miles up the McCloud River, on its left or western bank. It is one hundred and eighty-five miles from Sacramento City; three hundred and twenty-three miles from San Francisco via Pacific Railroad; four hundred and fifty-three miles from Portland, Oreg.; two hundred and seventy-two miles from Oakland, Oreg.; fifty miles from Red Bluff, Cal.; twenty-two miles from Redding, Cal. The point selected is on the California and Oregon stage-road, which, at the time of our arrival, connected with the railroad at Red Bluff. The railroad has now been continued to Redding, and it is thought that next year it will run within ten miles of the salmon-breeding station. The spawn found in the fish that the Indians were spearing on our arrival indicated that there was no time to spare in getting ready for the hatching-work. We were twenty-five miles from the nearest town or village, fifty miles from a railway station, over fifty miles from an available saw-mill, and in the Sierra Nevada Mountains, where the mule-teams barely made twenty miles a day with supplies; but we went to work, and in fifteen days we had a house built, filtering tanks, hatching apparatus, and flume in perfect running order, and on the 16th of September were catching and corralling the salmon. There were but three of us, and every day for a week the mercury ran from 105° to 112° F. in the shade. But although we worked so expeditiously through the broiling sun of those days, we were too late. The first few hauls of the net showed that the salmon had spawned. In fact, the salmon begin to spawn in the McCloud River some time in August, and are through spawning, or nearly through, by the 12th of September.

We caught plenty of salmon in the seine, but only rarely a female with ova. By hard fishing, and hauling the seine every night and sometimes all night, we succeeded in capturing twenty-six salmon, including both sexes, in spawning condition, by the 28th of September. On the night of the 28th, at midnight, as the returns did not seem to warrant the expense of handling the seine, I stopped fishing. Of the twenty-six breeding salmon caught, twelve were females and yielded about 50,000 eggs. Of this number 20,000 were destroyed by the terrible heat of the last of September; the mercury on some days reaching as high as 112° in the shade. The remaining 30,000 did well, in spite of many dangers from sediment, and from a fungoid growth which seemed to permeate the brook water on hot days, and which rendered constant vigilance necessary; and on the 12th day of October, the most advanced eggs showed the eye-spots. By Friday, October 18, all the

eggs were ready to pack for shipment, but owing to miscarriage of a letter the moss which was to be delivered on the previous Tuesday did not arrive until the evening of the following Tuesday. On the next day, October 23, the eggs were packed and shipped to Sacramento, where I placed them in charge of Wells, Fargo & Co., by whom they were forwarded East on the 25th of October, 1872.

2.—THE LOCATION OF THE SALMON-BREEDING STATION ON THE M'CLOUD RIVER.

The location which has been selected for this station seems to be the best, all things considered, that could be found for obtaining and maturing for shipment the eggs of the Sacramento River salmon. Although I made a careful exploration of the whole course of the Sacramento River, I found no place which seemed to me to possess equal advantages. The mill-brook at Tehama came the nearest to it, but at Tehama the salmon spawn so late as to throw the transportation of the eggs into December, when there is danger of snow-blockades on the Pacific Railroad; the rainy season commences at Tehama while the eggs are maturing, and renders the brook liable to become roiled by the rains; there is a mill on the stream, the operations of which would interfere with the water-supply of the hatching-troughs; and the fact that Indians, Chinese, and whites congregate there in great numbers to kill the salmon, makes the neighborhood anything but favorable for the delicate work of maturing salmon-eggs.

On the other hand, at the McCloud, the spawning period is such as to place the transportation of the eggs at the best time, viz, in Ooctober or November; the eggs will be shipped before the rainy season sets in, and if it did rain, it would not disturb the water of the McCloud river, which it is proposed to use in future. There is no mill nor anything else on the McCloud River to interfere with the water-supply, and, lastly, this river is wholly free from the rough neighborhoods which are found on the outskirts of a town like Tehama. The Tehama brook has the one advantage of being half a day's travel nearer Sacramento, but I do not think this a sufficient offset to the other advantages of the present location.

3.—CHANGES PROPOSED FOR ANOTHER SEASON.

I would recommend that next year the house and all the hatching apparatus be moved down close to the edge of the high-water mark of the river, where the seine is hauled for catching the parent salmon, and that the water for hatching be taken from the river itself. This can all be done at a very inconsiderable expense, and the whole thing will then be very compact. The fishing-ground, the dwelling-house, the corral for the parent salmon, and the hatching-works will all be close together, and a vast deal of labor and risk arising from these departments being separated, as they

were this year, will thus be saved. Last fall, when the works were put up, I did not know enough about the McCloud River to risk the proposed arrangement of the works, but I am satisfied now that it is both safe and very desirable. By this arrangement other advantages are gained besides compactness and convenience, for water will be obtained in unlimited quantities, of an even temperature, not varying over five degrees for two months. The water is as clear as crystal, and is *never* roiled from any cause whatever so as to deposit dangerous sediment; and lastly, this cold water of the McCloud, with a temperature of 48° to 53° F., will not grow the insidious fungus which continually showed itself in the warm water of the hatching-works of this last season. With these changes nine-tenths of the trouble and dangers of the past season will be avoided, and I see no obstacles in the way of very large success in obtaining salmon-eggs at this station in the future.

4.—WHY MORE SALMON-EGGS WERE NOT OBTAINED IN 1872.

The simple reason why more eggs were not obtained this season was because the salmon had spawned at the head-waters of the Sacramento before it was possible to get ready for the eggs. A subsequent effort might have been made at Tehama, but the lateness of the season, the uncertainty of the results, and the reduced condition of the appropriations, were sufficient to discourage it.

Although so small a return in the actual number of salmon obtained has been derived from the outlay attending this enterprise, the money can hardly be considered as unprofitably spent, for another and very adequate return is to be found in the actual preparations made for future operations and in the information and experience which have been obtained, and which, in the writer's opinion, are worth all they cost as a guide to future labors.

5.—CONDITIONS OF HATCHING SALMON IN CALIFORNIA COMPARED WITH SIMILAR OPERATIONS AT THE EAST.

The conditions of hatching salmon-eggs in California are wholly different from those which present themselves in similar work at the East.

At the East you have to guard against cold; in California you have to guard against heat; at the East you can usually find a good spring in a favorable locality; here it is out of the question; at the East a brook will usually answer the purposes of hatching-water in the absence of a spring; in California the brooks, as a rule, are wholly unsuitable for hatching; at the East the eggs are hatching in the winter; in California the salmon spawn in the summer; and, finally, most of the hatching work is done in California before the Atlantic fish begin to spawn.

6.—CATCHING THE SALMON IN THE M'CLOUD.

I tried three ways of capturing the parent salmon; first, by the Indian trap; second, by a stake-net and pound; third, by a sweep-seine.

The Indian trap consists of a fence of stakes or bushes, built out into the river, at a fall or rapid, in the form of a letter V, having the angle down stream, and a basket-trap at the angle. This method proved perfectly worthless, as of course it must, for catching healthy fish, as this contrivance catches only the exhausted fish that are going down the river, and none of the good fish that are coming up.

The second method of using a stake-net did not work on account of the volume and force of the river-current. I set the stake-net so as to just reverse the form of the Indian trap, that is, so that it formed a letter V with the angle *up stream*, and a trap or pound in the angle. As it happened, it was too late for such a net to be effective, because the salmon were all going down at that time, and none, or at most a very few, were coming up; but even if the salmon had been coming up, this contrivance would not have answered here as a permanency, because the velocity and volume of water in the McCloud are such as would ultimately tear any such net away, in any place where it could otherwise be set to advantage.

The third method, of sweeping with a seine, worked to perfection. In some of the holes, and especially in one large hole near which it is proposed to place the hatching-works next year, any number of parent salmon can be caught in the proper season. The only objection to hauling a seine in these places is, that as the boat taking out the seine turns to come ashore again, it is drawn near the brink of the rapids, over which it would be dangerous to go in the night. This is an objection, however, which skill and nerve can always overcome.

7.—TAKING THE EGGS.

When we fished where the corral or inclosure for the breeding salmon was situated, the salmon were taken carefully from the net as soon as it was hauled ashore, and placed in the corral, and kept there till the last haul was made, just before daylight. The eggs were then taken from the fish and impregnated, so that by the time the last haul was finished, and the net hung up to dry, the eggs were ready to be washed and placed in the hatching-troughs. This was all very simple, but when we hauled the seine at other points, where there was no place to confine the salmon, it was quite different. At these places, as soon as a spawning-fish was hauled to the shore, I took and impregnated the eggs at once, on the beach where we were, and kept the eggs in pails of water during the night, till we had got through seining. It took four men to strip a fish on these occasions; one to hold the head, one to hold the tail of the fish, and a third to take the eggs, while a fourth held a pitch-pine torch for light. On the darkest nights the scene on the river bank was exceedingly wild and picturesque. Behind us was the tall, deep shadow of Persephone Mountain, and before us at our feet ran the gleaming, rapid current of the McCloud, while the camp-fire threw an unsteady light upon the forest, mountain, and river, suddenly cut off by the dense

darkness beyond. The flaming pitch-pine torches, stuck into the sandy beach at intervals of 20 feet, to guide the boatman, the dusky forms of a half-dozen Indians coiled around the fire, or stoically watching the fishing, the net, the fishing-boat, and the struggling fish, added to the effect, and made a picture which, especially when the woods were set on fire to attract the salmon, was one of surpassing interest. It was quite impressive, in the midst of these surroundings, to reflect that we were beyond the white man's boundary, in the home of the Indians, where the bear, the panther, the deer, and the Indian had lived for centuries undisturbed.

The eggs were all taken in a dry pan, according to the new or Russian method of impregnation, and the milt of the male added immediately. Contrary to rule, I took a half a panful at a time instead of one layer, and stirred the eggs up with my hand, as you would stir up a pan of flour. After they were well mixed and had stood a minute or two, I filled up the pan with water, gave them another stirring, and left them from half an hour to an hour, at the end of which time I washed them, and poured them into a pail of water, to be taken to the hatching-troughs. When the eye-spots appeared, three weeks afterward, almost *every* egg was seen to have a fish in it, which proves two things: one is, that the dry method will impregnate almost, if not wholly, a hundred per cent. of the eggs; and the other is, that the old precaution, not to take over one layer of eggs in the pan at a time, is wholly needless. In fact, I believe I could take a ten-quart water-bucket half full of salmon-eggs at a time, without losing any more than by the one-layer method.

I found that the Sacramento River salmon (*i. e.*, the McCloud River salmon) yield their eggs much more readily than the Eastern salmon. It is not half the work to strip the fish, and they are in general more easily handled than the salmon of the Atlantic rivers.

8.—THE EGGS OF THE SACRAMENTO RIVER SALMON.

The eggs of the salmon of the Sacramento are larger and have a more reddish tinge than those of the Atlantic salmon. There are less eggs to the same weight of fish than with the eastern salmon, seven hundred eggs to each pound of the parent fish being a large average. We cannot yet tell how the period of incubation of these eggs compares with those of the Atlantic rivers, as it was impossible, with the varying temperature of the hatching-brook, to get at the exact average temperature of the water. I may say, however, that the eggs first showed the eye-spots in nineteen days, and that they hatched in forty-two days, and the *estimated* average temperature of the water was 58°–60° F.

9.—THE HATCHING-APPARATUS.

Our hatching-apparatus was all that could be wished. It consisted of twenty-four troughs of sugar-pine, 16 feet long, 12 inches wide, and $4\frac{1}{2}$ inches deep, the inside surface of which was converted to a coal by

charring. These troughs furnished almost 400 square feet of hatching space. There were three sets or tiers of troughs, one set below the other, with eight troughs arranged parallel to each other in each tier. There was a fall of three inches from one tier to another. The troughs were covered.

The filtering arrangement was quite perfect. It consisted of what the miners call a sand-box, which is merely an empty box to catch the heaviest of the sediment, and of two filtering-tanks proper. The water, after leaving the sand-box, passed through ten filters of sand and gravel and eight common filters of flannel.

All this provision for cleansing the water did not, however, prevent a fine fungoid growth from coming down with the water on to the eggs, which, when it was first discovered, had got such a start that its results must have been very disastrous had it not been for the ingenuity of my first assistant, Mr. John G. Woodbury, of San Francisco. Mr. Woodbury, on having his attention called to the condition of the eggs, suggested the very bold course of washing off the fungus with sand and water. The plan adopted was to put a few hundred eggs in a pail partly full of water, and having a handful of fine river-sand at the bottom. Upon holding this pail of eggs and sand under a stream of water, the whirling sand was brought into contact with the whirling eggs so constantly and rapidly, and yet so gently, that in a few minutes the fungus was entirely cleansed from the eggs, while the eggs were not injured in the least.

It would be a long and tedious job to go through this operation with many hundred thousand eggs, but with the few thousands which we had then laid down this ingenious contrivance answered its purpose admirably. It is proper to say that this plan was not tried till the spinal column of the fish had appeared; otherwise, even the gentle contact of the sand and water would probably have injured the less-matured embryo.

10.—PACKING AND SHIPPING THE EGGS.

The only moss that I could find or hear of was nearly seventy miles to the north, at the sources of the Sacramento, and the best of this moss grew just where one of the tributaries of the Sacramento bursts from the earth, at the base of Shasta Butte. This was the moss which I used for packing, and it was admirable. I packed the eggs in two common wooden boxes, holding about a cubic foot each. A soft but dense layer of moss, just as it grows, was first placed at the bottom of the box. A layer of eggs was then spread over the moss carpet, then a thin layer of moss, and so on, alternating to the top, as is the usual manner of packing ova, except that half way up the box a thin wooden rack or partition was put in to break the pressure of the upper layers. These two boxes being filled, and the covers being fastened on with screws, to avoid the concussion of driving nails, a dozen or twenty holes were bored in them to admit the air, and they were packed in an open wooden crate large enough to admit a layer of hay and straw four inches through

on all sides. This open space was filled with hay to weaken the force of concussions and to equalize the temperature inside. The cover of the crate was then put on, and I took them twenty-two miles down the stage-road to Redding, and thence one hundred and seventy miles by rail to Sacramento City, where, after unpacking the boxes and moistening the moss very thoroughly with cold water, I repacked the boxes in the crate, and shipped them East, in care of Wells, Fargo & Co., by way of the Pacific Railroad.

I packed two tin boxes of eggs, also, and inclosed them in pails of sawdust, with the expectation of hanging up the pails in the car, and so avoid in some degree the jolting of the trains; but on examining the car, and considering the number of changes of car between here and the Atlantic, I concluded that it was more dangerous to hang them up than to have them rest on the floor of the car. Accordingly, all the packages of eggs were carried like any other merchandise, on the floor of the express-car.

Permit me to add that, during the fall, I traveled the whole length of the Sacramento River, from its sources around Mount Shasta to its outlet at the bay of San Francisco, and also ascended the McCloud River as far as it is accessible, which is about twenty miles, and collected quite a complete series of specimens of the *Salmonidæ* of the Sacramento and McCloud Rivers, a catalogue of which I transmit herewith. The specimens and accompanying drawings have been forwarded to you, at the Smithsonian Institution.

B—THE SALMONIDÆ OF THE SACRAMENTO RIVER.

11.—THE SACRAMENTO RIVER.

In order to make what follows more clear, permit me to describe briefly the course of the Sacramento River.

The Sacramento River proper has its sources in Mount Shasta, and in the Siskiyou Mountains to the west of Mount Shasta, about four hundred miles by the river channel from its outlet into the ocean at San Francisco. A few miles below Mount Shasta, on Shasta Butte, as it is called in California, the smaller sources form a clear, rocky, and swift-running stream, about a hundred or a hundred and fifty feet across, and so deep that it can just be waded with high rubber boots at its shallowest parts. Its temperature is here very low, and probably does not average over 50° F. the year round. From this point, for nearly eighty miles, it falls at the rate of thirty-seven feet to the mile, running nearly due south, and retains its character of a clear and cold stream all the way. Down to this point it is known as the "Little Sacramento," and receives the waters of many small streams, but no large ones till it reaches its junction with Pitt River. At this stage of its course it has swollen to three times its original volume, and with the addition of the contents of Pitt River makes a stream six times the bulk

which it possessed just below Mount Shasta. It is still a clear river; but soon after passing this point it becomes roily, and continues to grow more and more so to its mouth. Above the mouth of Pit River it flows through a deep cañon, with high hills or mountains on both banks; but a short distance below the mouth of Pit River it enters a more level country, and from thence to the bay of San Francisco it moves slowly, widening every league, through a level country with broad sweeps of prairie on either side, now famous all over the world as the wonderfully productive region of the Sacramento Valley.

About a hundred and fifty miles below the mouth of Pit River it receives the muddy waters of the Feather River, and twenty miles farther down, at Sacramento City, the still muddier waters of the American Fork. From here to San Francisco the Sacramento River is navigable for large vessels and steamers; but receives no other extensive tributaries except the San Joaquin, which empties into it at Rio Vista, forty miles below Sacramento.

It will be seen by the above description that the Sacramento River has but four large tributaries, the San Joaquin, the American Fork, the Feather River, and Pit River. With the San Joaquin we have nothing to do in this report, as it may be regarded as almost an independent river, and has not come within the scope of the present investigation. I will only say in regard to this river that it is much warmer than the Sacramento, but is frequented somewhat by salmon, especially in the fall, which are killed in considerable quantities on some of its tributaries.

The American Fork was formerly a prolific salmon river, but the mining operations on its banks have rendered it so muddy that the salmon have abandoned it altogether, and none ascend it now. Precisely the same thing is to be said of Feather River. The salmon come up in some numbers to spawn in the smaller streams between the American and Pit Rivers, but the returns from these spawning-grounds are probably small. The salmon come up Pit River in great numbers in the spring, but I am informed that they all leave Pit River for the colder waters of the McCloud River in the latter part of June or the first part of July. It is probable that they ascend the upper waters of the Pit River also to a limited extent at this time, but I could obtain no positive information on this point. Above the mouth of Pit River the salmon ascend the Sacramento, now called the Little Sacramento, in great numbers, and make the clear waters of this stream the principal spawning-ground of the salmon of the Great Sacramento River, with one exception. This exception is the McCloud River.

12.—THE M'CLOUD RIVER.

This river, which is the great spawning rendezvous of the Sacramento salmon, deserves special notice both on this account, and because it is on this river that the United States salmon-breeding station has been located. The McCloud River heads in Mount Shasta and in the southern

slopes of the mountains, stretching away from Shasta Butte easterly and southeasterly toward the sources of Pit River. Its principal source is an immense spring, which bursts out from the southeastern flank of Mount Shasta, and at once forms a river from its own supply. This spring is fed by the melting snows of Shasta, and accounts for the unusual coldness and clearness of the McCloud River. The McCloud receives, near its source, a tributary about fifteen miles in length, coming from the northeast, but there are no other considerable streams emptying into it below, and it is said to have this peculiarity, that it is almost as large near its source as it is at its mouth. Through all its course it flows rapidly through a deep rocky cañon of the wildest scenery. The rocks and mountains rise up abruptly from its banks, in many places to the height of several thousand feet, and for ten or twenty miles near the middle of the river's course are inaccessible. On this account the river has never been surveyed throughout its whole course, and the river channel, as laid down on the maps, is wholly conjectural, for a considerable extent.

The McCloud River, near its mouth, where the salmon-breeding works are placed, averages about 60 yards in width, although in places it flows through gulches not over 30 feet wide, and in other places spreads out to a width of nearly a hundred yards. The temperature of the water is here, in September, 48°–49° at sunrise, and 53°–54° at sunset. It is singularly uniform in its temperature, and does not vary two degrees from these figures throughout October and November. The bed of the river is here rocky, gravelly and sandy, as it is throughout its whole course. The water is as clear as crystal and always rapid. The river begins to rise in December, and swells to a maximum height of 15 feet above the midsummer level. It is another peculiarity of this river, (and it can hardly be said of any other river in California,) that it has been abandoned to the Indians. The miner's pick and shovel have upturned the banks of other rivers, or the farms of white men have stretched along their waters, but, for some reason or other, the civilized races have very singularly left the McCloud River to its aboriginal inhabitants. The consequence is, that the McCloud River presents an instance of what is becoming extremely rare, at least in the more accessible portions of the country, namely, a region which is just as it was before the white man found it, and a race of aborigines, whose simple habits have not been corrupted by the aggressive influence of communication with the whites.

13.—THE M'CLOUD RIVER INDIANS.

The Indians themselves are a good-featured, hardy, but indolent race. I found them always pleasant, genial, and sociable, though, like other Indians, very sensitive when their pride was wounded. They at first adopted the plan of ordering all white men out of their country, and were the last of the California Indians to yield to the encroachments of civilization. Even now they are not slow to say to the white stranger, "These

are my lands," and "These are my salmon;" but the stern consequences of conflict with the whites have taught them to abstain from any violent vindication of their rights. They will still always revenge a wrong inflicted on them by their own people, and deem it a duty to avenge a murder of one of their kindred, but I think they are a well-disposed race by nature, and have no malice naturally in their hearts toward any one, and will not injure any one who does not first injure them. Every one told me, before my arrival and during my stay on the McCloud, that the Indians would steal everything that they could lay their hands on. I am glad that this opportunity is afforded me of bearing testimony to the contrary, which I wish to do very emphatically. I would trust the McCloud Indians with anything. We used to leave our things every day around the house, and even down on the river-bank, for weeks together, where the Indians could have stolen them with perfect safety, and where they would not have remained ten minutes *in a white man's settlement*, and yet I do not know of a single instance of theft of the smallest thing on their part, during all our stay of two months among them. On the contrary, in one instance, an Indian traveled six miles one hot day to return me a watch-guard, which he found in the pocket of a garment which I sold him, and which he might have kept with perfect impunity. And on another occasion, on the arrival of some gold coin, when I had reason to expect an attack from *white men*, I gave the gold to one of my Indians, and told him that I depended on him to protect that and me till morning. I slept soundly; and the next morning the faithful Indian handed me the gold just as I gave it to him. I wish on these accounts to be very emphatic in saying that the charges against these Indians of being a race of thieves, are untrue and unjust.

With all their good traits, however, murder did not seem to have the obnoxious character that it has among more enlightened people. Almost every McCloud Indian we met had killed one or more men, white or red, in the course of his life, but it was usually because they were goaded to it by ungovernable jealousy or revenge. It was not from motives of gain or causeless malice.

The McCloud Indians live and sleep in the open air in the summer. In the rainy season they build wigwams or huts of drift-wood and dry logs, which they inhabit pretty comfortably through the winter. In the summer and fall they live mainly on the salmon and trout which they spear. In the winter they live on the salmon which they catch and dry in the fall, and on acorns, which they gather in great quantities in the woods. They hunt with bows and arrows, with which they occasionally kill a bear, though a few of the more enterprising have rifles. They trap a very little, but the salmon of the river are so abundant that they are not obliged to resort to hunting and trapping at all, and do not do much of either.

I have made this long digression about the McCloud River Indians partly because their presence here is so singularly connected with the

abundance of the salmon in the Sacramento River. Had white men come here, and required the salmon for food, this main artery of the supply system of the river would have been stopped; or had white men come and engaged in mining, as they have done on the Yuba and on the Feather and American Rivers, the spawning-beds would have been covered with mud and ruined, as in those rivers, and in less than three years the salmon supply of the Sacramento would have shown a vast decrease. The presence of the Indians, therefore, as far as it implies the absence of the whites, is the great protection of the supply of the Sacramento salmon.

14.—THE CLIMATE OF THE M'CLOUD RIVER.

The rains come on a little earlier here among the mountains than lower down in the valleys, and continue a little later in the spring. It is wet, therefore, from November to May, and dry from May to November. The winters are mild, a very little snow falling occasionally with the rains. The summer and fall days are extremely hot, but the nights are cool, and in the fall are very cold compared with the days. In consequence of this the variations of temperature in the fall during the twenty-four hours are extreme. For many days together in September the mercury ranged from 55° Fahr. at sunrise to 105° in the shade at 11 a. m., making a variation of 50° in five hours. On some days the variation was 60°, and on one occasion nearly 70° in the same length of time. I have seen ice formed in our fishing-boat at night within ninety-six hours of a noon temperature of 110°. The hot days continue till November, and even extend into November. There were many successive days in October when it was over 100° in the shade. The hot hours of the day were usually from 11 a. m. till 4 p. m. From 8 a. m. to 11 a. m. the rise of temperature was very rapid, and from 4 p. m. to 7 p. m. the fall was equally rapid.

I have been speaking of the climate of the McCloud at our salmon station, near its mouth. As you ascend the McCloud the weather grows cooler, the rains last longer, and at its headwaters, in winter, there are deep snows.

15.—THE SACRAMENTO SALMON IN GENERAL.

The Sacramento salmon in its prime is a large, handsome, silvery fish, averaging about 20 pounds in weight, as they are caught at Rio Vista, the main fishing ground of the river.* These salmon have a darker shade and deeper bodies, and are less delicate in form, and slightly coarser in appearance than the Atlantic salmon. They are also heavier looking, less silvery, and probably less vigorous than the eastern salmon. It is so difficult to determine whether they differ from the eastern salmon in quality, as food, that it is quite safe to say that if they are not

*Salmon weighing from 40 to 50 pounds are not uncommon; and once in a great while one is caught exceeding 50 pounds in weight.

fully equal to their eastern kindred, as a table luxury, they are so near it, that the difference, if any, is not an important one. Their flesh in their prime is firm, sweet, rich, and juicy, and is certainly good enough to make them a desirable fish in any river in the world. (See question 79, p. 195.) As a game-fish they are active and powerful fighters, and are only conquered after a hard struggle. They are caught with a hook and line in salt and brackish waters, and also in the fresh waters of the upper tributaries. Salmon roe is the best bait in fresh water; but they will also take the artificial fly. Last July hundreds of salmon, averaging 15 pounds apiece, were caught in the Little Sacramento with a hook and line, near Frye's Hotel, at Upper Soda Springs, in Siskiyou County, California. It is not an uncommon but a common thing to catch salmon here with bait, which settles the question beyond dispute as to the Sacramento salmon biting at a hook in fresh water.

The Sacramento salmon, like all other salmon, fall off in size, weight, quality, and beauty from the time they enter fresh water. A week or two before they spawn they become very black, then smooth and slimy, their scales being absorbed into the skin. Soon after this they become foul, diseased, and very much emaciated, and in the McCloud River, at least, they die a short time after spawning.

16.—GENERAL MOVEMENTS OF THE SACRAMENTO SALMON IN THE LOWER PARTS OF THE RIVER.*

The prime salmon first make their appearance in the tide-water of the Sacramento, the early part of November. They are then very scarce, only three or four a day being at first caught at the great fisheries. They are at this time 18 cents a pound at wholesale, and 25 cents a pound at retail. They increase gradually in numbers, through November and December, and the retail price falls to 20 cents. By the middle of January they are somewhat more abundant in the bay, but few continue to be caught up the river. They remain scarce, or, rather, not abundant—more all the time being caught in the bay than up the river—until the 1st of March, when they begin to pour up the river in vast quantities. This flood of salmon lasts through March, April, and May, making these months the harvest months of the river fishermen,† both because the salmon are plentiful and because they are in good condition. The run culminates the last of April, or first of May. They are then the most abundant. They fall off from this time gradually in numbers and condition through May, and become comparatively scarce in June and July, and the first part of August. Before the end of August a

* It should be understood that the account given here and elsewhere in this report of the salmon of the main Sacramento river applies only to the salmon *above tide-water*.

† Eleven thousand three hundred and ninety-four salmon were sent down the river to San Francisco last March (1872) by one line of river-boats. It is estimated that five thousand more were salted on the river. This makes a yield of sixteen thousand three hundred and ninety-four fish, or about three hundred thousand pounds, in the month of March, making no allowance for other sources of outlet, which were considerable.

new run commences, and, to quote the fishermen's words, "the river is full of them." The quality of this fish is very poor compared with the winter and spring runs, which circumstance, connected with their great abundance, makes them a drug in the market at this time. They can now be bought at 3 cents a pound, and even for less, as tons of them are thrown back into the river for want of purchasers. This abundance continues through September, the quality of the fish remaining very poor. In October the numbers fall off again and continue to lessen, till the new winter run begins again in November.

The following table, according to months, shows the condition of the Sacramento River, in regard to the salmon, at Sacramento:

Month.	Numbers.	Quality.
January	Increasing, but not abundant	Prime.
February	Increasing, but not abundant	Prime.
March	Very abundant	Prime.
April	Very abundant	Nearly prime.
May	Falling off, but still abundant	Nearly prime.
June	Somewhat scarce	Inferior.
July	Somewhat scarce	Inferior.
August	Very abundant indeed	Very poor.
September	Abundant	Very poor.
October	Falling off. New run begins	Very poor.
November	Very scarce	Very fine.
December*	Scarce	Very fine.

17.—GENERAL MOVEMENTS, ETC., OF THE SACRAMENTO SALMON IN THE M'CLOUD RIVER.

It will be seen by the previous notes that there are salmon in the Lower Sacramento every month in the year. It is not so in the upper tributaries of the river, as for instance, in the Little Sacramento, or in the McCloud. The salmon have stated times for arriving in the upper tributaries and for remaining in them, and at other periods of the year there are no salmon in these streams.

The salmon arrive in the mouth of the McCloud in March, but are scarce in that month. In April and May they become plentiful but are not large, the average weight not exceeding ten or twelve pounds. They remain plentiful through June and July, during the latter part of which months they receive an accession from Pit River, the lower part of which river now becomes nearly deserted by the salmon. In August, there is a large run of salmon up the McCloud, composed of larger fish. The salmon are now, in August, the largest and most abundant of any time in the year in the McCloud. They begin to spawn in the lower portions of the McCloud during the last half of August. By the middle of September the salmon begin here to die, and from this till the end of the month they die very rapidly, and there are thousands of dead salmon floating down the stream and being washed up to the banks. The bears

* In December, January, and February, the salmon are more abundant in the lower parts of the river than further up.

now come down to the river in great numbers to eat the salmon, and the Indians stop spearing and go bear-hunting. About this time—the latter half of September—a new run of salmon makes its appearance in the McCloud, called the "fall run." They were not by any means plentiful this year, (1872,) but kept the river from being actually deserted by salmon for a month or more. During October there are no salmon in the McCloud, except the few new-comers of the "fall run," and by the 1st of November all the salmon are gone from the river except one or two individual stragglers here and there. By this time the Indians have all their salmon dried and packed away for winter. Some of the Indians have moved back into the woods, while those that remain on the river have built little wigwams of drift wood, to protect them from the winter rains, and have gone into winter quarters. From November till March there are no salmon in the McCloud River.

All I could learn about the young salmon in the river was that in May the young fry, about two inches long, are very abundant. Soon after this they wholly disappear, and their destination is unknown. During my stay on the McCloud through August, September, and October, I saw no small fish which I recognized as young salmon, nor could I learn from any source where the young salmon were. Their whereabouts at this season still remains a mystery.

18.—CONDITION OF THE SALMON DURING THEIR STAY IN THE M'CLOUD RIVER.

In March, when the salmon first arrive in the McCloud, they are in fine condition. They are now bright and silvery, with shining scales. They are fat and excellent for the table, but not large. The spawn in the females is very small. Their flesh is of a deep-red color. The males and females are almost indistinguishable at this time. This state of things remains till August, except that the salmon gradually deteriorate in quality, and the eggs increase in size. The first marked change in the fish takes place a little before the middle of August. The salmon then become very black. The males grow deep and thin, and the dog-teeth begin to show themselves, and to increase rapidly in size. The females are now big with spawn, and the sexes are easily distinguishable. From this time they rapidly deteriorate. Their flesh shades off to a light, dirty pink. They become foul and diseased, and very much emaciated. Their scales are wholly absorbed into the skin, which is of a dark olive hue, or black. Blotches of fungus appear on their heads and bodies, and in various places are long, white patches where the skin is partly worn off. Their fins and tails become badly mutilated, and in a short time they die exhausted. By the 1st of October most of the fish that were in the river in August are dead. The height of the spawning-season in 1872 was about the 8th of September. The salmon had begun to spawn when I arrived on the McCloud, the 30th of August. By the middle of September nearly all the salmon had spawned, except the "fall run."

Table showing the movements, condition, etc., of the Sacramento salmon in the McCloud river in each month of the year:

Months.	Numbers.	Quality.	Remarks.
January....	None..............	....	Trout now spawning.
February...	None..............	....	River very high.
March	Very few..........	Prime..............	Do.
April.......	Abundant..........	Prime..............	Trout have scarlet bands.
May	Abundant..........	Falling off slightly..	Young salmon fry abundant.
June.......	Abundant..........	Falling off slightly..	First appearance of salmon at head-waters of Little Sacramento.
July	Abundant..........	Considerably deteriorated.	Begin to spawn at head-waters.
August	Very abundant	Large fish, but black and poor.	Begin to spawn on lower McCloud.
September..	Very abundant but dying rapidly.	Foul, emaciated, and mutilated.	Gone from head-waters.
October	All dead except fall run.	Fall run, considered not bad.	Trout will not bite on McCloud.
November ..	None but one or two stragglers.	....	First rains.
December ..	None..............	....	Trout ascend small streams in great numbers.

Table showing the condition of the ova of the salmon at the head-waters of the Little Sacramento, (Mount Shasta;) at the Lower McCloud; at Tehama; at Rio Vista and Sacramento City, and at Eel River, Humboldt County, California.

Months.	CONDITION OF OVA AT—				
	Mount Shasta.	McCloud.	Tehama.	Sacramento City and Rio Vista.	Eel River.
January..	No salmon.....	No salmon.....	No salmon..	Very small.....	Ripe.....
February.	No salmon.....	No salmon.....	No salmon..	Very small.....	....
March....	No salmon.....	Small..........	No salmon..	Very small.....	....
April.....	No salmon.....	Small..........	....	Larger.........	....
May......	No salmon.....	Larger.........	....	Larger.........	....
June......	Quite large....	Larger.........	....	Larger.........	....
July	Ripe...........	Well developed.	....	Quite advanced.	....
August...	Ripe...........	Ripe...........	....	Very large	....
September	Spawning season over.	Ripe...........	....	Very large	....
October...	Spawning season over.	Spawning finished. Salmon dead.	Ripe.......	Very large	....
November.	Spawning season over.	Spawning finished. Salmon dead.	Ripe.......	Very small.....	....
December.	Spawning season over.	Spawning finished. Salmon dead.	Spawning season over.	Very small.....	Ripe.....

19.—ANSWERS TO QUERIES CONCERNING THE SACRAMENTO SALMON, GIVEN IN THE ORDER OF PROFESSOR BAIRD'S PRINTED LIST OF QUESTIONS ENTITLED "QUESTIONS RELATIVE TO THE FOOD FISHES OF THE UNITED STATES.

(The capital letters indicate the topics; the figures refer to the questions.)

A.—NAME.

Question 1. What is the name by which this fish is known in your neighborhood? If possible, make an outline sketch for better identification.

Answer. The salmon of the Sacramento River which are caught at or below Sacramento City are known by the name of the Sacramento salmon. The salmon which are caught above Sacramento City take the name of the stream or the locality at which they are caught, as, for instance, the salmon caught in the mill-brook near Tehama are called Tehama salmon. So with the McCloud salmon and Pit River salmon, although all these fish are the proper Sacramento salmon. The grilse is very often called the *salmon-trout*, which confusion of names is likely at first to mislead a new-comer. In every instance which came under my observation on the tributaries of the Sacramento I found that *salmon-trout* invariably meant only a salmon grilse, with the single exception of the *wye-dar-deekit*. (See No. 27 and No. 68 of the catalogue of specimens.)

The spawning male salmon of the tributaries is called the *dog-salmon* or *dog-toothed salmon*, and is supposed by the uninformed to be a different fish from the Sacramento salmon, though it is the same in a different stage.

The Indian names for the McCloud salmon in their different stages are as follows:

Salmon	Nóo-oolh.
Male salmon	Charrk.
Female salmon	Kó-raisch.
Grilse	Kó-riùlch.
Black salmon	Choo-lóo-loo nóo-oulh.
White (emaciated) salmon	Aée-teppem.
Late "Fall salmon"	Eée-par-téppem.
McCloud salmon	Winni-māme nóo-oolh.
Young salmon fry	Kóo-ootét nòo-oulh.
Salmon eggs	Poo-oop.
Salmon skin	Nóo-oolh irritcha.
Dead salmon	Min-nal noo-oolh.

(For outline sketch of salmon see drawings accompanying the Smithsonian specimens.)

B.—DISTRIBUTION.

Question 2. Is it found throughout the year, or only during a certain time; and for what time?

Answer. Salmon are found in the Sacramento River, at and below Sacramento City, at all times of the year. They are found in the McCloud River from March to November. (See tables, pp. 181 and 183.)

Question 3. If resident, is it more abundant at certain times of the year; and at what times?

Answer. Salmon are most abundant in the Lower Sacramento in March, April, May and August. In the McCloud, they are most abundant in August.

C.—Abundance.

Question 4. How abundant is it, compared with other fish?

Answer. Salmon in the Sacramento are much more abundant than any other fish.

Question 5. Has the abundance of the fish diminished or increased within the last ten years, or is it about the same?

Answer. The fishermen say that the salmon in the river are as plentiful as ever they were, (although I see that the California fish commissioners report differently,) and that if anything they have been more abundant the last three years. The year 1866 was an exceptional year. The salmon were then very scarce, the river being almost destitute of them. The fishermen attributed it to the unusually muddy water of the river, caused by the mining that year. Some thought that there was a falling off in 1864 and 1865, but they are not all agreed on this point. In 1867, the salmon were as abundant as ever in the Sacramento River, and have remained so since.

It should be stated here that the salmon which used to abound in the Feather and American Rivers have been wholly driven out by the mining, without, however, appearing to affect the abundance of the salmon in the main river.

Question 6. If diminished or increased, what is the supposed cause?

Answer. See question 5.

Question 7. What is the amount, or extent, of the change in abundance?

Answer. See question 5.

D.—Size.

Question 8. What is the greatest size to which it attains, (both length and weight,) and what the average?

Answer. The greatest size to which the Sacramento salmon attain is from 50 to 60 pounds. Mr. S. R. Jones, of Sacramento City, has seen one caught at that point that weighed 51 pounds. He says he has heard of one, at San Francisco, weighing 60 pounds. Salmon weighing between 40 and 50 pounds are not uncommon. The average weight seems to be about 20 pounds for spring-salmon, and 23 pounds for summer-salmon. The longest salmon that I saw, measured 38 inches. This length is probably seldom exceeded much. I should judge the average length of the salmon to be about 30 or 32 inches.

Question 9. State the rate of growth, per annum, if known; and the size at one, two, three, or more years.

Answer. The rate of growth per annum is not known. The grilse in the McCloud River, which were supposed to be eighteen months old, measured from 18 to 24 inches in length. The theory is that salmon are full-grown at the age of about three years. It is also known that the young salmon in the McCloud, in May, are 2 or 3 inches long, from which the following conjectural table may be formed:

	Length.
Young fry, a few months old	2 or 3 inches.
Grilse, eighteen months old	18 to 24 inches.
Salmon, about three years old, (average)	30 inches.

Question 10. Do the sexes differ in respect to shape, size, rate of growth, etc.?

Answer. During the fresh runs of the winter and spring, the sexes differ very slightly, if any, in shape or general appearance. The male may possibly be a little more curved in the jaws, and a little less plump along the sides of the abdomen, but these differences are but slightly defined. The difference is also very slight through the summer, but in the fall the distinctions of the sexes are very marked. The now fully developed ova of the female gives her sex a peculiarly rounded and plump appearance, and the shape and expression of her head does not change much. On the other hand the male grows very deep and thin. His head flattens, his upper jaw curves like a hook over the lower, his eyes assume a peculiarly sunken and malicious expression. Large, powerful white teeth, like dog's teeth, appear on both jaws, and the whole creature acquires an ugly and ferocious appearance. As to the comparative rate of growth of the two sexes, although I have not noticed that the males are larger than the females in winter and spring, I have always observed that they are considerably larger in the spawning season. Allowing the average age of both sexes to be the same, it would consequently appear that the rate of growth of the males is greater than that of the females.

E.—Migrations and movements.

Question 11. By what route do these fish come in to the shore; and what the subsequent movements?

Answer. All the fishermen agree that most of the Sacramento salmon come down the coast from the North. On arriving at the mouth of the river they spend some time in the bay of San Francisco. Two weeks after their arrival in the bay, they make their appearance at the head of tide-water. At this point they seem to wait some time, the fishermen being of the opinion that they play about here for a period, and actually go up a little ways into fresh water and return to tide-water again. It is more than four months after their appearance in the bay of San Francisco before they enter the colder tributaries of the river, as, for instance, the McCloud and Little Sacramento, one hundred and seventy miles north of the head of tide-water. They do not reach the sources

of the Sacramento for two or three months after entering the mouth of the McCloud and Little Sacramento. There are, therefore, seven months between the first appearance of the salmon at the mouth of the Sacramento and their arrival at its sources four hundred miles above. They leave the sources of the river by August, the colder tributaries by September, the Sacramento proper by November or December, during which latter months the new winter run is beginning to come up.

Question 12. By what route do they leave the coast?

Answer. Not known.

Question 13. Where do they spend the winter season?

Answer. Mostly in the ocean. There are a limited number in the winter in the bay of San Francisco and tide-waters of the Sacramento.

Question 14. When are the fish first seen or known to come near the shore, and when does the main body arrive; are the first the largest; are there more schools or runs than one coming in, and at what intervals?

Answer. The salmon first appear inshore in November, (the winter run.) The main body arrives at the head of tide-water in March and April, (the spring run.) There is another large run up the river in August, (the summer run.) The first are the smallest; the last run, in August, are the largest. There are three annual runs of salmon up the main Sacramento; the spring run, beginning in March; the summer run, beginning in August, and the winter run, beginning in November. The intervals between the runs are as follows: From winter run to spring run, no interval; from spring run to summer run—May to August—two months, the beginning of the spring run joining on to the end of the winter run. From summer run to winter run—September to November—one month.

Question 15. When do the fish leave shore, and is this done by degrees, or in a body?

Answer. Not known.

Question 16. Is the appearance of the fish on the coast regular and certain, or do they ever fail for one or more seasons at a time, and then return in greater or less abundance? If so, to what cause is this assigned?

Answer. The appearance of the salmon at the mouth and at different points of the river is quite regular, a variation in the runs of two weeks, depending on the rains, (early and copious rains bringing early runs,) being the greatest irregularity. Their appearance is also very certain, the year 1866 being the only year since California was settled when the salmon did not run up the river as usual. This year they were very scarce. The fishermen, in their wish to represent it strongly, say, "There were no salmon in the river in '66." They attribute the extraordinary dearth of salmon that year to the muddy water, occasioned by the mining. The rains affect the running of the salmon to a limited degree, in two ways—the earlier the rains come, the earlier the salmon ascend the river, and the greater the rain-fall, the longer the run of fish.

Question 17. How do the runs differ from each other in number and size?

Answer. The winter run is small, and consists of comparatively small fish. The spring run is larger, and contains larger fish. The summer run is the largest of all, and is composed of the largest fish.

Question 18. Which sex comes in first; and how far advanced is the spawn in the female on first arriving?

Answer. It is not known which sex comes first. The spawn is exceedingly small when the first salmon come in from the ocean in November. It is larger in the spring run, and still larger in the summer run.

Question 19. Will either sex, or both, take the hook on first arriving; and if so, is there any period of the stay of the fish when they refuse it?

Answer. The salmon of both sexes take the hook in salt and brackish water and at the fresh and cold sources of the tributaries, but at no intermediate place that is now known.

Question 20. If they refuse the hook at first, how soon do they begin to take it after arriving?

Answer. See 19.

Question 21. Do the schools of fish swim high or low; and is their arrival known otherwise than by their capture; that is, do they make a ripple on the water: do they attract birds, &c.?

Answer. In winter the salmon swim low; in summer they are in all depths of the water. The water is so muddy in the Sacramento that they are only discovered by their capture. In the cold tributaries forming their spawning-grounds they are seen by thousands in the water, and jumping out of the water, and swimming with the dorsal fin cutting the surface.

Question 22. What is the relation of their movements to the ebb and flow of the tide?

Answer. The salmon are generally moving against the tide. The fishermen watch the tide, and fish *with* it, so as to encounter the salmon swimming toward the net.*

Question 23. Does spawn ever run out of these fish taken with a hook?

Answer. The spawn sometimes runs from the salmon taken with a hook at the head-waters of the Little Sacramento.

Question 24. Answer same question in regard to fish taken in nets or pounds; is the spawn ever seen in any quantity floating about inside of nets?

Answer. The spawn never flows from the salmon caught in nets, except when they are taken on their spawning-beds.

Question 25. Are these fish anadromous; that is, do they run up from the sea into fresh water for any, and for what, purpose?

*The water of the main Sacramento is so muddy that the fish cannot see the net till close upon them; consequently the fishing in this river can be done in the day-time, while in all other clear rivers the nets must be drawn at night.

Answer. Yes. They run up into fresh water to spawn.

Question 26. If anadromous, when are they first seen off the coast when do they enter the mouths of the rivers, and what is the rate of progression up stream?

Answer. See question 11, p. 186.

Question 27. If anadromous, what is the length of their stay in fresh water, and when do they return to the sea?

Answer. See question 11, p. 186.

Question 28. Do the different sexes or ages vary in this respect?

Answer. Not known.

Question 29. Do these fish come on to the breeding-grounds before they are mature; or do you find the one or two year old fish with the oldest?

Answer. Male grilse, small and large, are found on the breeding-grounds, with the mature fish, but I have never seen a female grilse on the spawning-grounds or anywhere else.

Question 30. What are the favorite localities of these fish; say whether in still water or currents; shallow or deep water; on the sand; in grass; about rocks, &c.?

Answer. As a rule, I think the salmon keep in holes, and in deep and sheltered places. When they are spawning, or getting ready to spawn, they leave the holes and stay on the rapids.

Question 31. What depth of water is preferred by these fish?

Answer. They prefer generally the deepest water they can find in the rivers, except when spawning, and then they are seldom found in more than four or five feet of water, and are satisfied with less than will cover their dorsal fins.

Question 32. What the favorite temperature and general character of water?

Answer. In spawning they seek a temperature below 55° F., and do not avoid a temperature as low as 45°. The temperature of the lower McCloud was 48° at sunrise and 53° at sunset, during the spawning-season. The mercury falls two or three degrees below these figures on the spawning-grounds of the sources of the Little Sacramento. The water in the McCloud and Little Sacramento is very clear, swift, and cold. The water of the main Sacramento is always muddy.

F.—Relationships.

Question 33. Do these fish go in schools after they have done spawning; or throughout the year; or are they scattered and solitary?

Answer. The salmon always go in schools. Whenever they are found solitary and scattered it is because there are too few to make a school.

Question 34. Have they any special friends or enemies?

Answer. The seals and sea-lions are very destructive to the salmon in the salt water. Cuts and scars are often seen on the salmon, where they have been bitten by seals. They eat the bodies and leave the

heads. Eleven salmon-heads were once caught at Wood's Island, from which the bodies had been eaten by seals. Fishers and otters, and fish-hawks, also destroy them in fresh water, but not enough to affect their numbers much. They have no friends that I am aware of, except fish-culturists and fish-commissioners.

Question 35. To what extent do they prey on other fish; and on what species?

Answer. Their food is similar to that of the Atlantic coast salmon while they are in the salt water; but they eat nothing in fresh water.

Question 36. To what extent do they suffer from the attacks of other fish, or other animals?

Answer. See question 34, p. 189.

G.—Food.

Question 37. What is the nature of their food?

Answer. See question 35.

Question 38. Are there any special peculiarities in the manner of feeding of these fish?

Answer. They eat nothing in fresh water, but probably eat voraciously in the ocean, their growth in salt water being so extremely rapid.

Question 39. What amount of food do they consume?

Answer. See question 38.

H.—Reproduction.

Question 40. Is there any marked change in the shape or color of either sex during the breeding-season; or any peculiar development of or on any portion of the body, as the mouth, fins, scales, &c.?

Answer. At the spawning-season the changes, especially in the male salmon, are very marked. Both sexes lose their bright and silvery coat. Their scales become absorbed into the skin, which grows very slimy and perfectly smooth, like that of a catfish or horn-pout. Their color changes into a dirty black, and then into a dark, unclean olive color. Blotches of fungus, and large patches of white, caused by abrasion of the skin, appear all over them. Their fins and tail become mutilated. Their bodies grow foul and emaciated. (The head of the male changes as described under question 32.) Their eyes get more or less injured; they often become blind; swarms of parasites gather in their gills, and stick to their fins. Their bodies reach the extreme point of attenuation, and, as soon as the spawning is accomplished, they die.

Question 41. Are there any special or unusual habits during the spawning-season?

Answer. They lose their shyness at the spawning-time, so that they will not avoid a person standing a few feet from them, at the water's edge. I attributed this to their state of great exhaustion.

Question 42. Is spawning interfered with by lines or nets, or otherwise?

Answer. Not at all on the McCloud and "Little Sacramento." At Tehama the salmon are *all* destroyed by fishermen, or nearly all.

Question 43. At what age does the male begin to breed; and at what age the female?

Answer. Probably the male begins to breed eighteen months after hatching. The female probably does not breed till one year later. (See question 29, p. 189.)

Question 44. For how many years can these fish spawn?

Answer. No one knows. It is certain, however, that the salmon of the McCloud and Little Sacramento do not spawn but once in *those rivers*, for they all die after spawning. If they ever spawned before, it must be somewhere else, and they can never spawn again. There were fish in the McCloud this fall, 1872, that seemed to be several years old. They died like the rest, and it is a puzzling question where they spent the two or three previous years. Other puzzling questions are called out as, for instance, Why did they not come into the McCloud last year? If they went elsewhere last year, why did they not go to the same place this year? If all the salmon die after the first spawning, how is the stock of mature fish kept up? &c., &c. These questions must remain unanswered for the present. The fact alone remains that ninety-nine one-hundredths, if not all of the salmon in the upper tributaries of the Sacramento River, appear to die immediately after their first spawning in those streams, unless the few stragglers of the "fall run" be an exception.

Question 45. Does the act of spawning exert an injurious effect?

Answer. Whatever the effect of the spawning may be, it is certain that the spawning fish die as soon as it is over.

Question 46. Where do these fish spawn, and when?

Answer. The Sacramento salmon spawn as follows: At the sources of the river, in July; in the Little Sacramento and in the McCloud rivers, in August; at the mouth of the McCloud, in September; in smaller tributaries of the main river at and below Tehama, in October and November.

Question 47. Can you give any account of the process: whether males and females go in pairs, or one female and two males; whether the sexes are mixed indiscriminately? &c.

Answer. The fish pair off and spawn very much according to the common descriptions of the spawning of other salmon. The males are very aggressive at this season, and are always attacking other fish near them.

Question 48. Is the water ever whitened or colored by the milt of the male?

Answer. Never to a noticeable extent.

Question 49. What temperature of water is most favorable for hatching?

Answer. 45° F. to 50° F.

Question 50. At what depth of water are the eggs laid, if on, or near he bottom?

Answer. The eggs are laid on the bottom, usually in from 1 foot to 4 feet of water.

Question 51. What is the size and color of the spawn?

Answer. The spawn are very large, being not far from a quarter of an inch in diameter. Their color is a deep salmon-red.

Question 52. What is the estimated number for each fish; and how ascertained?

Answer. In the McCloud the number of eggs averaged about 700 to each pound of the parent fish; a 10-pound fish giving 7,000 eggs. This was ascertained by weighing the fish and counting the eggs.

Question 53. Answer the question for one season, and for the lifetime?

Answer. See question 52.

Question 54. Do the eggs, when spawned, sink to the bottom, and become attached to stones, grass, &c., or do they float in the water until hatched?

Answer. See question 55.

Question 55. Do the fish heap up or construct any kind of nest, whether of sand, gravel, grass, or otherwise; and, if so, is the mouth, the snout, or the tail used for the purpose, or what; and, if so, how is the material transported; or do they make any excavation in the sand or gravel?

Answer. The parent salmon dig a nest in the gravelly and stony bed of the river, with their tails and heads, and, having laid their eggs, they cover them over with stones and gravel in the same way. The McCloud salmon did not pile up the gravel and stones over their nests as much as the eastern salmon, but left them more level.

Question 56. Do they watch over their nest, if made, either singly or in pairs?

Answer. They do not watch over their nests.

Question 57. When are the eggs hatched, and in what period of time after being laid?

Answer. The salmon-eggs in the McCloud probably hatch in October and November, or about sixty days after being deposited.

Question 58. What percentage of eggs laid is usually hatched?

Answer. No one knows.

Question 59. What percentage of young attains to maturity?

Answer. No one knows.

Question 60. What is the rate of growth?

Answer. See question 9, p. 185.

Question 61. Do the parents, either or both, watch over the young after they are hatched?

Answer. The parents are dead long before the young are hatched.

Question 62. Do they carry them in the mouth, or otherwise?

Answer. See question 61.

Question 63. What enemies interfere with, or destroy, the spawn or the young fish? Do the parent fish devour them?

Answer. Water insects, water fowl, trout, suckers, white-fish, and *possibly* the water ouzel. See question 61.

Question 64. Are the young of this fish found in abundance, and in what localities?

Answer. The young fish are found in great abundance in the neighborhood of the spawning-ground in May, and probably before. After the month of May they suddenly and mysteriously disappear.

Question 65. On what do they appear to feed?

Answer. They probably feed on crustacea, water-insects, and smaller fish.

I.—ARTIFICIAL CULTURE.

Question 66. Have any steps been taken to increase the abundance of this fish by artificial breeding?

Answer. No steps have been taken to increase the Sacramento salmon in the Sacramento river by artificial breeding. The United States has a salmon-breeding station on the McCloud river, one of the tributaries of the Sacramento, but the object of this station is to obtain salmon-eggs for the Atlantic rivers, and not to replenish the Sacramento. Several thousand impregnated salmon eggs were successfully sent to the Atlantic coast from this place this fall, 1872, and have been hatched successfully. The destination of these young salmon is the Susquehanna river.

K.—PROTECTION.

Question 67. Are these fish protected by law, or otherwise?

Answer. The Sacramento salmon are protected by a law imposing penalties on the use of weirs, pounds, or other fixed engines of capture, giant powder, and small-meshed nets. The Rio Vista and Sacramento fishermen wish for a law prohibiting salmon-fishing with nets, from the 1st of June till the beginning of the winter run in November. This seems to me to be a very judicious way of regulating the fishing, whenever it is thought best to regulate it by law. During the time mentioned, from June to November, the salmon are very poor, the fishermen make poor wages at fishing, and tons of spoiled salmon are thrown back into the river for the want of a market.

The supply of the Sacramento salmon has a singular natural protection arising from the fact that the McCloud river, containing the great spawning-grounds of these fish, is held entirely by Indians. As long as this state of things remains, the natural supply of the salmon stock of the Sacramento may be considered as guaranteed. That this protection is one of no slight importance may be inferred from the fact that the appearance of the white man, on the American and Feather rivers, two great forks of the Sacramento, has been followed by the *total destruction* of the spawning beds of these once prolific salmon-streams, and the spoiling of the water, so that not a single salmon ever enters these rivers now where they used to swarm by millions in the days of the aboriginal inhabitants. I earnestly hope that the policy which has been pursued

with the Modoc Indians, against whom a war of extermination is now going on, just north of the McCloud river, will never be adopted with the McCloud River tribe. It would be an inhuman outrage to drive this superior and inoffensive race from their river, and I believe that the best policy to use with them is to let them be where they are, and if necessary, *to protect them from the encroachments of the white men.*

L.—DISEASES.

Question 68. Has any epidemic, or other disease, ever been noticed among them, such as to cause their sickness or death in greater or less number?

Answer. No particular epidemic or disease has been observed, that I am aware of, among the Sacramento salmon. The breeding-salmon in the upper tributaries all die after spawning, but this is to be attributed to their great emaciation and exhaustion, consequent upon having been so long away from salt water, and not to disease, properly so called.

Question 69. When have these epidemics taken place, and to what causes have they been assigned?

Answer. See Question 68.

M.—PARASITES.

Question 70. Are crabs, worms, lampreys, or other living animals found attached to the outside, or on the gills of these fish?

Answer. A worm-like parasite attacks the salmon in fresh water, and gathers in vast multitudes in their gills toward the close of the spawning-season. They also fasten on their fins to some extent. I have not noticed other parasites on the salmon.

N.—CAPTURE.

Question 71. How is this fish caught; if with a hook, what are the different kinds of bait used, and which are preferred?

Answer. The Sacramento salmon is caught with nets, spears, Indian traps, and with the hook. In the smaller tributaries of the main river, as at Tehama, they are killed with shovels, pitch-forks, clubs, and every available weapon. In the upper tributaries, as the McCloud, the Indians catch them in traps, arranged to capture the fish going down the river exhausted, but not those ascending the river. At the sources of the river, near Mount Shasta, they are caught by legitimate angling with a hook. Salmon roe is almost exclusively used for bait. Some have been taken with the artificial fly.

Question 72. If in nets, in what kind?

Answer. The salmon-fishing at the great fisheries in the main river is done wholly with drift-nets. These are gill-nets, which, when stretched across the river, are drawn or drifted up or down *with* the tide. The salmon are caught, of course, by the gills in the meshes of the net.

Question 73. At what season and for what period is it taken in nets, and when with the line?

Answer. The salmon are always caught in the main river with nets, all the year round. They are taken with the hook at the sources of the river, chiefly in July.

Question 74. What would be the average daily catch, of one person, with the hook, and what the total for the season?

Answer. The average daily catch, at the head-waters of the Sacramento, near Upper Soda Springs, with the hook and line, is about a dozen salmon, weighing, on the average, 15 pounds apiece.

Question 75. Answer the same question for one seine or pound, of specified length.

Answer. Mr. William Hamilton, of the Schwartz fishing-grounds—a fair specimen of the smaller fishing-grounds of the main river—caught 15 salmon a day during the regular fishing-season, from March 1 to June 1, with a common drift-net.

Question 76. Is the time of catching with nets or pounds different from that with lines?

Answer. Nets are used all the year round. Hook and line are used in fresh water only, in July.

Question 77. Is it caught more on one time of tide than on another?

Answer. I believe the fishermen draw their nets chiefly at the turn of the tide.

O.—Economical value and application.

Question 78. What disposition is made of the fish caught, whether used on the spot or sent elsewhere; and if so, where?

Answer. All the salmon that are caught in the main river, including the bay, are sold *fresh* in the San Francisco, Sacramento City, and other home markets, if possible. This includes, probably, about all that are caught in the winter and three-fourths of those caught in the spring. Those that do not find a sale as fresh-salmon, are to some extent salted down, and the rest are thrown back into the river.*

The Indians on the upper tributaries dry their salmon and store them up for their winter food. It is unnecessary to say what the anglers do with theirs.

Question 79. What is its excellence as food, fresh or salted?

Answer. The Sacramento fresh salmon, when prime, is a fish of great excellence as food. The flesh is firm, juicy, rich, and delicious. After taking pains to form a careful and correct opinion on the subject, I am unable to say that it is in any degree inferior, when in its best condition, to the Atlantic salmon, in its best condition. I think the common opinion is the other way, and I account for it as follows: The Atlantic

* On the 26th day of August, I saw 600 pounds of spoiled salmon at one fish-market at Sacramento City, which were about to be thrown into the river.

salmon are only sent to market in June, July, and August, when they are in their very best condition. The *average*, therefore, is of a very fine quality. On the contrary, the Sacramento salmon are in the market every month in the year, whether prime or not, and are the cheapest and *most common* when they are the poorest, in consequence of which the *average* Sacramento salmon of the markets the year round is a very ordinary fish. Now, people generally, unless their attention is specially called to the subject, when forming their opinion of the comparative merits of the two kinds of salmon, involuntarily compare the *average* Sacramento salmon with the *average* Penobscot salmon, and are compelled to decide in favor of the latter. I think this is the reason why the Sacramento salmon is held to be an inferior fish. I was myself, before my arrival here, much prejudiced in favor of the Atlantic fish, and the Sacramento salmon, which I ate in August, confirmed my prejudice; but now, having eaten and carefully judged of the quality of the winter run or prime salmon of the Sacramento River, I resign my prejudice against these salmon, and state with confidence that I do not consider them in any respect inferior in quality to their Atlantic kindred.

The same remarks apply in general to the salted salmon of the Sacramento.

Question 80. How long does it retain its excellence as a fresh fish?

Answer. These salmon do not differ from other salmon in respect to the length of time that they will remain fresh and sweet. They can be kept fresh two weeks, and even more, on ice, especially when prime.

Question 81. To what extent is it eaten?

Answer. The Sacramento salmon are universally eaten, and the extent of their consumption is very great.* One line of steamboats brought 400,000 pounds of Sacramento salmon into San Francisco in March, 1872.

Question 82. Is it salted down, and to what extent?

Answer. It is estimated that 25,000 salmon were salted down on the Sacramento River last spring, (1872,) and 9,000 last fall. This, however, includes all that were salted, both from the catch above tide-water and below it.

Question 83. Is it used, and to what extent, as manure, for oil, or for other purposes, and what?

Answer. It is not used to any extent as manure, for oil, or other purposes than for food.

Question 84. What were the highest and lowest prices of the fish, per pound, during the past season, wholesale and retail, and what the average, and how do these compare with former prices?

Answer. The highest price during the last year for Sacramento salmon was 25 cents per pound, wholesale, and 18 cents, retail. The lowest price, wholesale and retail, ran from 5 cents to nothing. The average price

* See note at bottom of page 197.

through the year has been about 10 cents. These are gold figures. The price has not varied much the last few years.

Question 85. Are these fish exported; and if so, to what extent?

Answer. The Sacramento salmon are not exported at all, or only in a few exceptional instances, the home demand being sufficient to exhaust them.

Question 86. Where is the principal market of these fish?

Answer. The principal market for them is the City of San Francisco.

20.—OTHER SALMONIDÆ OF THE SACRAMENTO RIVER.

The other *Salomonidæ* of the Sacramento (main) River are confined to one variety, which some call a salmon, but which the fishermen think is a mountain-trout, which has dropped down the river farther than usual. It is described in my catalogue of Smithsonian specimens under Nos. 12 and 13. It is quite rare in the Lower Sacramento.

The common mountain-trout is found in abundance in all the cold tributaries of the main river, and probably other varieties which have not been reported.

21.—OTHER SALMONIDÆ OF THE M'CLOUD RIVER.

Besides the salmon, there are, in the McCloud, three other varieties of *Salmonidæ*: 1, the common mountain-trout; 2, the *wye-dar-deeket*; and, 3, the "silver-trout." A full series of specimens of the first variety has been collected and sent to the Smithsonian Institution. (See catalogue of specimens.) This fish is delicious eating, when prime, and is quite abundant in the river, and ascends the small tributaries of the river in vast quantities, to spawn, in the winter.

The second variety is very rare in the Lower McCloud, but abundant at its head-waters, and being a very handsome and delicious fish, is the favorite fish for fifty miles around. (See No. 27 and No. 68 of Catalogue of Smithsonian Specimens.)

The third variety I only heard of as being at the sources of the McCloud. It was described to me as a round, plump, silvery trout, and not rare.

I will here add that the other fish of the Sacramento (main) River are the white-perch, Sacramento pike or white-fish, (a cyprinoid,) sturgeon, chub, hard-heads, split-tails, (herrings,) suckers, mud-fish. Of these the white-fish, sucker, and mud-fish are found in the McCloud River. (See Catalogue of Specimens.)

22.—LIST OF INDIAN WORDS OF THE M'CLOUD DIALECT.

Although it does not properly come within the scope of this report, I take the liberty to append a few words of the dialect of the McCloud

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* I am informed by the fish-dealers in San Francisco that 10,000 fresh salmon a week are sent into that city from the San Joaquin and the Sacramento Rivers in August, when salmon are the cheapest and most abundant.

Indians, for the sake of preserving something of a language which will soon become extinct. Without expecting to save them, I picked up these words casually from the Indians last fall, (1872,) while getting the salmon-eggs, and, meager as the list is, I believe it is the only collection of words of the McCloud Indians that has been made:

LIST OF WORDS.

Indian	Wintoon.
White man	Yi-patoo.
No	Éllo.
Yes	Ho.
Yes, (emphatic)	Urmāno.
Very	Bóo-ya.
A great many	Bóo-ya.
Large	Bo-hā-ma.
Small	Koo-oo-tett.
Cold	Teém-ma
Warm	Peé-lár-ma.
Live	Móoruch-béer.
Dead	Min-nâl.
I, me, mine, my	Nett.
You, your, him, her, his, hers	(Non ego) mutt.
North	Wy-ee.
East	Pôu-ey.
South	Norrh.
West	Num.
Day	Sannie.
Morning	Horn-heema.
Evening	Nó-monnie.
Night	Ken-wahnie.
Dark	Chéepy.
Sleep	Kéen-na.
Sleepy	Keen-ka.
Breakfast	Himmár-bar.
Dinner	Sannie-bar.
Supper	Kenwannie-bar.
To-morrow	Hímmar.
Yesterday	Lénder.
Head	Píll-yoak.
Eye	Toohio.
Mouth	Oó-ool.
Face	Toom.
Hair	Tom-moi.
One	Két-tett.
Two	Párr-la.
Three	Pahn-oulh.
Four	Clów-ett.
Five	Sánsigh.
Six	Set-panoulh.
Seven	Ló-lochett.
Eight	Sét-clow-ett.
Nine	Kétett-élless.
Ten	Tickalouss.
Fish	Déek-et.
Salmon	Noo-oohl.
Trout	Syee-oolott.
Salmon-trout	Wye-dar-deeket.
Salmon-eggs	Poo-oop.
Sacramento white fish.	Chóo-sûs.
Male salmon	Charrk.
Female salmon	Kō-raisch.
Black salmon	Choo-lóo-loonóo-oolh
White, (emaciated) salmon.	Aée-teppem.
Late-fall-salmon	Eée-par-teppett.
McCloud salmon	Winny-māme hoo-oolh.
Grilse	Kóo-rilsh.
Salmon-fry	Kóo-ootett noo-oolh.
Dorsal-fin	Khō-rōhl.
Adipose-fin	Toohw-keeh.
Pectoral	All-āle-i-kóbol.
Anal	Kén-tee-kóbol.
Caudal	Pwár-tolh.
Gills	Khár-nee.
Man	Wintoon.
Woman	Mō-hālee.
Boy	Wéetah.
Girl	Pochtílah.
Infant	Pickaninny.
Wife	Poích-ta.
Sweetheart	Poich-ta.
Hand	Semm.
Foot	Semm.
Arm	Khée-dett.
Horse	Horse.
Cow	Cow.
Bear	Cheelkh.
Grizzly bear	Wée-mar.
Hog	Hor-róichta.
Deer	Nopp.
Beaver	Só-chett.
Otter	Māme-tóolich.
Mink	Bíes-syooss.
Coon	Ca-ráillett.
Fisher, (cat)	Yúpokos.
Water-dog, (lizard)	Hée-sollett.
Water-ouzel	Soúr-sínny.
Gun	Kō-lool.

Bow	Kō-lool.
Arrow	Nott.
To shoot	Yoopcha.
Will shoot, (future)	Yoopcha.
Have shot, (past)	Yoopcha.
Spear	Káy-ell.
To spear	Dídt-ley.
To spear a salmon	Noo-oolh didt-ley.
To shoot a deer	Nopp yóop-cha.
To catch	Perri-mahn.
To catch a trout	Syee-oolott perri-mahn.
House	Boss.
River	Même.
Water	Même.
Salt	Welche.
Ocean	Welche mêmе, or bohāma mēme.
Sacramento River	Bohaima mêmе.
Fire	Pohrr.
Bread	Chów-tráss.
Flour	Chów-tráss.
Acorns	Klích-ly.
Wood	Chûsse.
Tree	Mee.
Tobacco	Lo-ole.
Knife	Kelly-kelly.
Acorns, growing	Peurmalh.
Blanket	Jackloss.
Looking-glass	Ken-wiúnas.
Shirt	Winnem-coddie.
Rain	Lóo-hay.
To rain, (verb)	Lóo-hay.
Sand	Pomm.
Country	Pomm.
Flowers	Lóo-lich.
Buckskin, tanned	Táy-ruch.
Buck-eye, (nut)	You-nott.
Money	Péss-sûs.
Mountain	Bo-haima pil-yokh.
Long	Charrua.
Short	Wor-óhter.
Good	Chálla.
Bad	Chip-kálla.
New, (clean)	Illa.
Dirty	Bóo-koolah.
To see	Wínn-neh.
To come	Widder.
To go	Harra.
Have gone	Harra.
Will go	Harra.
Stay	Bóoha.
Rest	Bóoha.
Sunday, (rest day)	Sannie booha.
A week	Ketett sannie booha.

To bring	Wérrell.
To pay	Doo-ya.
To give	Doo-ya.
To stand	Hick-í-yah.
To give	Kóot-eh.
To want	Squéea.
To eat	Bar.
To be hungry	Bar-squeea.
To drink	Boolah.
Intoxicated	Whisky-Boolah.
To drink spirits	Whisky-bar.
To strike	Kóopah.
To chop	Kóopah.
To steal	Khí-yah.
To remain	Pomadilly.
To reside	Pomadilly.
To sit down to rest	Kéltnah.
To buy	Poolah.
To work	Kléet-ich.
To be tired	Klee-tich-et.
To sew	Hoóray.
To skin	Írritīcha.
To skin a deer	Nopp írritcha.
To be afraid	Khée-lup.
To like	Hī-hīna.
To love	Hī-hina.
To kiss	Ell-chóopcha.
To swim	Méme-tulich.
To row (a boat)	Méme-tulich.
To understand	Tipna.
To know	Tipna.
To know	(Spanish) sáp-beh.
To talk	Teen.
All	Komm.
Same	Pée-yanny.
Other side	Poo-yelty.
Opposite bank of river.	Poo-yelty māme.
This side	Num-ílty.
Chief	Wee-ee.
Stars	Klóo-yook.
Straight	Kéllar.
Bye and bye	Pôp-ham.
Black	Choo-loo-loo.
White	Kī-yah.
To have	Bemen.
How	Hen-nōnie.
How many	Híssart.
When	Héssan.
How long	Héssan.
Where	Hécky.
Here	Éh-weh.
What	Pày-ee.
Say, (tell me)	Hád-die.
I don't know	O-oo.

I don't care	Héster.
Deer-skin	Nopp-nickol.
Deer-stew	Nopp-clummiss.
North star	Wye-dar-werris.
Sick, (at the stomach)	Técklich-kóolah.
Thread	Thee-put.
McCloud River	Wínnie-máme.
My land	Net Pomm.
When you come	Hessan mut widder.
Atlantic Ocean, (far east salt water.)	Káll-ale-poo-ay welkh mame.
Come again.	Way-ai-worr-ry.
Good bye, (the idea of going, simply.)	Harrá-dar.
Let us go; come on	Harrá-dar.
Moon	Sass.
One month; next month.	Ketett sass.
Thank you—(simply "good.")	Chálla.
Bring a salmon to my house.	Mut widder net boss noo-oolh.
Good Indian	Chálla wintoon.
Bad white man	Chípkalla yí-patoo.
Do you want to see my gun?	Mut winner sqeea net kolool.
Coming	Well-árbo.
Come in and sit down.	Éll-ponah kéltnah.
San Francisco, New York, or any distant place, (far-off land.)	Kéll-ale pomm.

Spanish words used by McCloud River Indians.

These words are spelt as the Indians pronounce them.

Much	Móocha.
Small	Chikéeta.
To know	Sáh-beh.
Man	Moochácha.
Cluster of Indian lodges.	Ranchery.
Money	Pês-sous.

C.—CATALOGUE OF NATURAL HISTORY SPECIMENS, COLLECTED ON THE PACIFIC SLOPE, IN 1872, BY LIVINGSTON STONE, FOR THE UNITED STATES FISH COMMISSION.

No. 1. Skin and head of fish, caught in Green River, near Green River Station, (Pacific Railroad,) August 6, 1872. Weight about three-quarters of a pound. Common name, "Buffalo-fish," "White-fish," "Green River Sucker." (See note.) (See drawing.)

No. 1. Green River, at this station, has an elevation of 6,140 feet. The surrounding country has a very barren and desolate appearance, as if nothing could live there. Fortunately for the few inhabitants of the place, this fish, together with suckers, abound in the waters of Green River, and are here caught in considerable quantities with a small sweep-seine.

No. 2. Common California brook-trout; San Pedro brook, twenty miles south of San Francisco. Yearling. August 17, 1872. These fish spawn in the San Pedro brook in March and April. Abundant. (See note.) Contributed by California Acclimatizing Society.

No. 2. The California Acclimatizing Society has its headquarters at San Francisco, and its ponds at San Pedro Point, in San Mateo County, twenty miles south of San Francisco. Its officers for 1872–'73 are: Dr. W. A. Newell, 632 Mission street, president; John Williamson, 632 Mission street, secretary. This society has successfully introduced from the East the black bass (*Grystes fasciatus*) and the brook trout, (*Salmo fontinalis.*) They have also succeeded in hatching and raising artificially a large number

of Lake Tahoe trout and California brook-trout, (*Salmo iridea.*) The society has received several orders recently from Australia and New Zealand for a large number of the eggs of the California *Salmonidæ.*

No. 3. Same as No. 2.

No. 4. Lake Tahoe trout. Common name, (Tahoe) "shore-trout." Yearling. August 16, 1872. Very abundant at Lake Tahoe. This one was hatched artificially at the ponds of the California Acclimatizing Society in April or May, 1871. Contributed by California Acclimatizing Society.

No. 5. Same as No. 4.

No. 6. Six specimens of young fry, hatched in April, from parents taken from San Andrea's reservoir, and reared at California Acclimatizing Society ponds. August 17, 1872. Contributed by California Acclimatizing Society.

No. 7. Six specimens of California brook-trout. San Pedro brook. Young fry, August 17, 1872. (See drawing.) (See note.)

No. 8. Skin and head. Common name, San Andrea's lower reservoir trout. Weight, 8 pounds. Length, 26 inches. Girth, (just in front of dorsal,) 17 inches. Peculiar to the lower reservoir of the San Andrea's ("Spring Valley") water-works. (See note.) The fattest and heaviest trout of its length that I ever saw. Easily landed, and died very quickly. There were about 500 separated and fully-developed eggs of last spring's roe lying loosely in the abdomen. The natural spawn of the next season were quite small—perhaps the size of pin-heads. This fish is rare, and is the only *large* trout caught in the lake. Silvery. No colored spots. Caught with *chub* bait. August 20, 1872.

No. 8. This was a fine specimen of its kind, and one of the largest ever taken. The "reservoir" in which it was caught is an artificial body of water, several miles long, formed by building a dam across the San Andrea's brook, and used to supply the city of San Francisco with water. The appearance of this fish in the reservoir was a surprise, as no fish of that size had ever been known about there before. It is thought by some to be a salmon, accidentally shut in from the sea by the dam, and by others to be a trout, which favorable circumstances bring to this unusual size. The reservoir absolutely swarms with *chubs*, about six or eight inches long, which form the food of these large fishes. It is a singular fact that the upper reservoir, a short distance above on the same stream, contains only the common trout of the usual size.

No. 9. Silver trout. San Andrea's lower reservoir. Rather rare. Very much resembles salmon smolt. Never caught large. Beautiful form.

No. 10. Viscera of No. 8.

No. 11. Two specimens. Utah mountain-trout. Young fry. Salt Lake City trout-ponds. Hatched artificially. Parents taken in Bear River. Abundant in Bear River and Bear Lake, and other cold mountain waters in Utah. Hatched in April, May. Period of incubation, very short. August 9, 1872. (See note.) Contributed by A. P. Rockwood, superintendent fisheries Salt Lake City.

No. 11. The Salt Lake City trout-ponds are fed by springs and spring streams, which contain the *clearest* and *purest* water that I have ever seen. Indeed, in these respects, the water is very extraordinary. It will run for six months without depositing sediment or growing fungus. Water-cress and other water-plants grow in this water with a rankness and luxuriance that is wonderful. Although the water must contain alkali, it is vastly superior to any water that I have ever seen on the Atlantic or Pacific slopes for breeding and rearing trout.

There is a fine lot of the native Utah trout at this establishment, which is confined at present to the hatching and rearing of the native varieties, viz, Utah mountain-trout and Utah Lake trout. The place is carried by the city government, and is in charge of the Mormon superintendent of fisheries, Mr. A. P. Rockwood.

No. 12. Sacramento River trout. Sacramento River at Sacramento City. Rare. Female. August 26, 1872. (See drawing.) This variety sometimes attains a large size, being occasionally as large as the smaller salmon. They are called salmon by some. Mr. S. R. Jones, of the Sacramento fish-market, and a good authority, thinks that they are mountain-trout which have accidentally dropped down the river to this point. They are caught here chiefly in the fall, and when the winter rains come on they disappear again.

No. 13. Sacramento River trout. Male. August 26, 1872. See No. 12. (See drawing.)

No. 14. Pharyngeal teeth of "Sacramento pike." August 26, 1872.

No. 15. Viscera of No. 12.

No. 16. Viscera of No. 13.

No. 17. Salmon grilse. September 3, 1872. McCloud River. Very deep and thin. Head, tail, back, and fins black. Very black all over when dry, except on belly.

Dimensions.

	Inches.
From snout to fork in tail	18
From snout to end of tail	19
Girth	$8\frac{1}{2}$
Head	4

Abundant. Scales absorbed into skin, and skin very slimy. Flesh soft, but eatable. Many parasites in gills. (See drawing.) (See note.)

No. 17. The word "girth" in the catalogue, when used without explanation, means the measurement taken just in front of the dorsal fin.

No. 18. Viscera of No. 17. Testes, or milt glands, were not saved; but they were very large and full, with milt flowing copiously from them.

No. 19. Salmon grilse. Male. Body deep and thin. McCloud River, California, September 5, 1872. Very black and slimy. Gills full of parasites. Looked foul. Greenish yellow sores in flesh, under the skin. Weight, 4 pounds. (See drawing.)

Dimensions.

	Inches.
Length, snout to tip of tail	24
Length of head	4
Girth	11
Girth of head	10
Girth of tail, (at smallest part)	4

Weight, 4 pounds.

No. 20. Viscera of No. 19. Milt well developed and prime.

No. 21. Trout. Indian name, *syóolott.* McCloud River. Female. September 7, 1872. Small head and beautiful form. Capital eating. Quite common.

Dimensions.

	Inches.
Length, from snout to tip of tail	15¼
Length of head	1½
Girth	8½
Girth of head	5½
Girth of tail	3

Spawn considerably developed. There were nearly one-half pint of salmon eggs in this trout's stomach when caught. This was the best fish for eating that we found while on the McCloud. (See drawing.)

No. 22. Trout, *syóolott,* McCloud River, September 7, 1872. In poor condition compared with No. 21; but in better condition than No. 23. Stomach one-quarter full of salmon-eggs, which is the bait used by the Indians for catching them. Eggs less developed than those of No. 21. On the whole a lank-looking fish, with comparatively large head, but not bad eating. This one, I believe, was speared by the Indians. (See drawing.)

No. 23. Trout. (Indian) *syóolott.* Said by the Indians to be the common mountain-trout, like the previous specimens. McCloud River, September 7, 1872. Thin, emaciated, and in very bad condition. Very large head, compared with body. Dorsal fin mutilated. Flesh looked unhealthy. Eggs very small and diseased. Organs of exit ulcerated and swollen. NOTE.—Fish (trout) similarly diseased are occasionally found at artificial trout-breeding ponds. The Indians said that Nos. 21, 22, and 23 were the same fish, though found in such different condition. (See drawing.)

No. 24. Viscera to No. 21.

No. 25. Viscera to No. 22.

No. 26. Viscera to No. 23.

No. 27. Common name, salmon trout; Indian name, *wye-dar-déekit.* McCloud River, September 7, 1872. Also called at Soda Springs the "Varden" trout. (See No. 68.)

Dimensions.

	Inches.
Length, snout to tip of tail	$17\frac{1}{4}$
Girth	9

Meat firm and hard, but rather dry; tasted very much like No. 8. The handsomest trout, and, on the whole, having the most perfect form of all the trout we saw on the McCloud. Also, the only fish that had colored spots. This one was profusely spotted over most of the body with reddish golden spots. (See drawing.) Possibly the *Salmo spectabilis*, Pacific Railroad Reports, vol. xii, p. 342–3. (See note.) Only a medium table-fish, at this season. Rare.

No. 27. This trout is rare in the lower waters of the McCloud, but common at its head-waters. Fishermen say that this trout is caught nowhere else in California. It is considered a great luxury at Soda Springs, on the Little Sacramento, from which place parties often travel the fifteen-mile trail to the Upper McCloud to catch it. Mr. I. F. Frye, of Soda Springs, once caught a mountain-trout of two pounds on his hook, and as he was just in the act of pulling it out of the water, it was seized by a monstrous *wye-dar-deékit*, which Mr. Frye says could not have weighed less than 20 pounds. The latter fish was lost, but the mountain-trout showed the marks of his teeth on both sides.

No. 28. Viscera to No. 27.

No. 29. Male salmon. McCloud river, California, September 23, 1872. A clean, healthy, nice-looking fish, but not silvery. This fish belongs to a class which are just beginning to come up the river, in limited numbers, called the fall run. Their flesh is quite palatable and good, and there is considerable fat on them still. Their scales have usually been absorbed, and the surface of the skin is smooth and slimy. These are the only salmon now coming up the river. All the others are floating down the river, dead or dying. The milt of this fish was well developed and flowing. Girth, 15 inches. (See drawing.)

No. 30. Large, full-grown male salmon. September 25, 1872, McCloud River, California. Weight, 20 pounds; girth, 21 inches; girth at anus, $16\frac{1}{2}$ inches; length, 38 inches. (Consult *Salmo canis*, W. Pacific Railroad Report, vol. xii, p. 341.) (See drawing.) (See note.)

No. 30. This fish was *one of the largest, if not the largest*, which we saw on the McCloud. He was thin and worn, but would have weighed nearly 40 pounds when in good condition.

No. 31. Viscera to No. 30.

No. 32. Male salmon. McCloud River, September 25, 1872. Girth, in front of dorsal, 16 inches; at anus, 13 inches. No drawing was taken of this fish.

No. 33. Viscera to No. 32.

There is no No. 34.

No. 35. Grilse. The skin was accidentally scraped somewhat with a knife. September 25, 1872, McCloud River, California.

No. 36. Grilse. McCloud River, Sêptember 25, 1872.

No. 36. Head of male salmon. McCloud River, September 25, 1872.

No. 37. Head of male salmon. McCloud River, September 25, 1872.

No. 38. Head of male salmon. McCloud River, September, 25, 1872. Probably an old fish.

No. 39. Head of female salmon. September 25, 1872.

No. 40. Trout. The common mountain-trout of California. Indian name *syóolott* McCloud River, September 27, 1872. This is a beautiful specimen of the species.

No. 41. Mountain-trout. McCloud River, September 26, 1872. (See note.)

No. 41. The common mountain-trout is easily caught at most seasons of the year, with almost any seasonable bait, and also, and quite as successfully, with the artificial fly. The Indians also spear them. It is, however, hard to catch them on the Lower McCloud after the 1st of October. (See report on salmon-breeding.)

No. 42. Same as 41.

No. 43. Female salmon. McCloud River, September 28, 1872. This fish had spawned; was foul, emaciated, and with tail almost worn off. A fair specimen of the fish which are now floating down the river, dead or exhausted. Weight 10 pounds. (See drawing.)

No. 44. Female salmon. McCloud River, September 27, 1872. Weight, 7 pounds. This fish had not spawned when caught. The drawing was taken after spawning the fish. She had 4,500 eggs. (See note.) (See drawing.)

No. 44. The less number of ova in the McCloud salmon, compared with the eastern salmon, was very noticeable. I never found over 700 eggs to the pound in the McCloud salmon. On the other hand, the eggs were larger than those of the Atlantic salmon.

No. 45. Male grilse. McCloud River, September 27, 1872. Foul, but a fair specimen. Abundant, though not so much so as the full-grown salmon. (See note.)

No. 45. I did not find a single female grilse among the great numbers of grilse which I examined and saw on the McCloud; nor have I ever seen a female grilse elsewhere, although I have seen persons who said they had seen them.

No. 46. Young trout. Indian name *kóo-ootét syo-lott*="small trout." McCloud River, September 29, 1872.

No. 47. Yellow sucker. McCloud River, September 29, 1872. Abundant. (See note.)

No. 47. The other fish of the McCloud River besides the (1) salmon are the (2) common mountain-trout, (3) *wye-dar-déeket*, (see No. 48,) (4) white-fish, (cyprinoid?) (5) common sucker, (6) yellow sucker, (see No. 72,) (7) mud-fish, (8) silver-trout? Headwaters of McCloud.

The above are all the fish that are found in the McCloud River in September, October, and November.

No. 48. Common name on the McCloud, "white-fish;" common name on the Sacramento, "Sacramento pike." McCloud River, September 29, 1872. Abundant.

No. 49. Viscera to No. 48.

No. 50. Same as No. 48. These fish are caught with salmon roe, and are very abundant at this season. (See drawing.) They grow here to an average weight of one or two pounds; but in the warmer waters of the Lower Sacramento, say at Sacramento City, they attain a very large size. Their flesh is sweet and good, but soft and bony.

No. 51. Viscera to No. 50.

No. 52. Female salmon. Indian names, *mohalie no-oolh* = *she* or woman-salmon, and *kōraisch* McCloud River, September 30. Weight, 18 pounds. Girth, 18¾ inches. This is a "fall run" fish, and is larger than the average of the "fall run," but not larger than the average of the summer-salmon.

No. 53. Red-headed woodpecker. McCloud River, California, October 8, 1872. Contributed by Hon. B. B. Redding.

No. 54. Snake. Head-waters of Sacramento, October 10, 1872. Contributed by B. B. Redding.

No. 55. Trout. Indian name, *syóo-lott.* Sometimes called the red-banded trout. Little Sacramento River at Upper Soda Springs, October 10, 1872. This trout has an almost scarlet band, extending the whole length of the body, and about as wide as one-fourth the depth of the fish. The band overlies the lateral line, and is about evenly divided by it. The Indians say that it is the common mountain-trout, and that the scarlet band is found on some, but not on others. (See note.)

No. 55. The scarlet-banded trout appears to be the same as the common mountain-trout, the scarlet band being an accidental feature, dependent upon seasons and localities. For instance, on the coast it is rarely seen in its full brightness; in the Lower McCloud, the trout have it in June, and it continues to grow more vivid and deeper-colored till the middle of August, when it leaves them altogether, and does not show itself at all in September and October. Again, at the head-waters of the Sacramento, the golden band is on the trout all the year round, and it is probably the same with the trout at the head-waters of the McCloud. The bright scarlet band is so rare on the coast that the trout fishermen call it a different variety, and esteem it an unusual prize. (See No. 64, catalogue.)

No. 56. Red-banded trout. Head-waters of Sacramento, near Mount Shasta. Temperature of water, 46° F. The trout caught in these cold waters are very fine. October 10, 1872.

No. 57. Red-banded trout. Head-waters Sacramento, near Mount Shasta, October 10, 1872.

No. 58. Same as No. 57.

No. 59. Red-banded trout. Little Sacramento. Upper Soda Springs, October 10, 1872.

No. 60. Same as No. 59.

No. 61. Same as No. 59.

No. 62. Same as No. 59.

No. 63. Same as No. 59.

Among these specimens of red-banded trout, is one skin and head not designated, of which there is a drawing.

No. 64. Red-banded trout. Little Sacramento, at Frye's Upper Soda Springs, October 9, 1872. Abundant. Caught all the months in the year. All the trout at this part of the Sacramento have the red band at all seasons of the year. These trout are caught with artificial fly, and the ordinary trout-fishing bait; salmon roe being found the most effective of the natural bait. Mr. Sisson says that the flesh of these fish is sometimes white and sometimes red. Mr. Frye says that this is the same trout that he has caught all the way up and down the California coast.

No. 65. Red-banded trout. October 9, 1872. Little Sacramento River, near the hotel kept by Mr. Isaac F. Frye, at Upper Soda Springs.

No. 66. Same as No. 65.

No. 67. Same as No. 65.

No. 68. Common name, salmon-trout. McCloud. Indian name, *wye-dar-déek-it*, which means the fish from the North, this variety being caught only in the head or northern waters of the McCloud. The local name at Soda Springs is the "Dolly Varden" trout. Head-waters of the McCloud River, September 1, 1872. This specimen is salted, and is the same as No. 27, but in the lower waters of the McCloud, where No. 27 was caught, it is rare and exceptional, while at the head-waters of the river it is common. (See note.) The spawn in this fish were large and almost ripe. These fish are thought to sometimes attain a size of 20 pounds. One was caught which weighed 5 pounds; another which weighed 11 pounds. They are considered very fine eating at Soda Springs. The salted one which I ate was certainly very fine. (See No. 27.)

No. 68. I was told that at the head-waters of the McCloud, there is a beautiful silvery trout beside the "Dolly Varden," called the "silver-trout." (See note to No. 47.)

No. 69. There is no number 69.

No. 70. Trout. October 10, 1872. Head-waters of the Sacramento.

No. 71. Water-ouzel. October 10, 1872. Indian name *sours-sinny*. Head-waters Sacramento, October 10, 1872. At a distance the water-ouzels seemed to be almost the color of the rocks on which they stand and look for food. They have a peculiar note like a child's rattle, but at times sing beautifully.

No. 72. Mud-fish. McCloud River, October 31, 1872.

No. 73. Small mud-fish. McCloud River, October 31, 1872.

No. 74. Young trout. McCloud River, October 31, 1872.

No. 75. Same as No. 74.

No. 76. Trout. Wentworth's brook. This brook empties into the

McCloud on its east side, about thirteen miles above its mouth. There are a ranch and cabin here, occupied by the only white resident of the McCloud River, Mr. Frank Wentworth. November 1, 1872.

No. 77. Same as No. 76.

No. 78. There is no No. 78.

No. 79. Salmon. Female. Mill-brook, near Tehama, on the Sacramento River, November, 7, 1872. Abundant. This is a small stream, where the salmon rush up to spawn in great numbers, in October and November. They also come up this brook in April, May, and June. They resemble in many particulars, in outward appearance, the "fall run" of the McCloud River. This point is fourteen miles below the head of navigation of the Sacramento River, which is here quite deep and broad. The water of the main river is roily here. (See note.) (See drawing.) Girth, 20 inches. Weight 16½ pounds.

No. 79. At Tehama, in the fall, the salmon are speared and trapped in great numbers, and many are sent to the San Francisco and Sacramento markets, salmon from other sources being very scarce at this time. These spawning-fish, however, are seldom offered for sale in the first-class markets, and are not eaten by the initiated. They are in demand, however, at the more common restaurants and eating-saloons.

No. 80. Salmon. Male. Mill-brook, near Tehama, on the Sacramento River. Abundant. November 7, 1872. These fish were in their prime for spawning the last week in October. At this date many had spawned, but many, also, of this run, had spawn and milt in them. Weight, 5¾ pounds; girth, 13¾ inches. (See drawing.)

No. 81. Same as No. 80. Male, weight 13 pounds; girth 18½ inches. (See drawing.)

No. 82. Salmon. Female. Mill-brook, near Tehama. Weight, 10¾ pounds; girth, 16½ inches. November 7, 1872. (See drawing.)

No. 83. Salmon grilse. Male. Mill-brook, near Tehama, November 7, 1872. Weight, 4½ pounds; girth, 12⅝ inches. (See note.) (See drawing.)

No. 84. Salmon. Female. Mill-brook near Tehama, on Sacramento River, November 7, 1872. Weight, 10¾ pounds; girth, 16 inches. This fish had perfect or nearly perfect scales, and a somewhat silvery appearance. The eye will be seen in this specimen to be larger than that of the other specimens. Salmon with unabsorbed scales are very rare at this season, and at this distance from the sea. I did not find one on the McCloud from September 1 to November 1 that had scales like those on this specimen. (See drawing.)

No. 85. Tom-cods. San Francisco Bay, November 16, 1872.

No. 86. Common name on Pacific coast is smelts. San Francisco Bay, November 16, 1872.

No. 87. Shrimps. San Francisco Bay, November 16, 1872. (These creatures lived longer in the alcohol than anything I have seen except lizards.)

No. 88. Octopus. Common name among the fishermen is squid. I

suppose this is the *picuvre* of Hugo's "*Les Travailleurs de la Mer*," or *poulps*. Farallone Islands, November 15, 1872. Occasionally caught on this coast. The fishermen speak of it with dread, and evidently consider it very formidable. This specimen was not considered a very large one; yet it must have been much larger than the one Hugo describes, as this one has over 1,200 suckers to 400 of his specimen. Adams speaks of one caught near the Meia-cashimah Islands as a very large one, because it could cover an area of 12 feet in circumference. The arms of this one were about 4½ feet long, and could cover an area at least 28 feet in circumference. The Italian fishermen consider them good to eat, and very good, too. The ink-bag was quite full, and had, I should say, over a half a pint of fluid in it.

No. 89. Trout. McCloud River, November 2, 1872.

No. 90. Rock-perch. Near Goat Island, San Francisco Bay, November 18, 1872.

No. 91. Porgee. Near Goat Island, San Francisco Bay, November 18, 1872.

No. 92. Salt-water trout. San Francisco Bay, November 18, 1872.

No. 93. Rock-perch. San Francisco Bay, November 18, 1872.

No. 94. Rock-perch. San Francisco Bay, November 18, 1872.

No. 95. Salt-water trout. San Francisco Bay, November 19, 1872.

No. 96. Salt-water trout. San Francisco Bay, November 19, 1872.

No. 97. Spider. Near Mount Shasta, October 10, 1872.

No. 98, No. 99. There are no Nos. 98 and 99.

No. 100. Three specimens. White-fish, Russian River, Mendocino County, California, September, 1872. Contributed by J. Williamson.

No. 101. Herring. Five specimens. San Francisco Bay, November 22, 1872. Males very full of milt.

No. 102. Rock-fish, rock-cod. Three specimens. San Francisco Bay, November 22, 1872.

No. 103. Rock-fish, rock-cod. Yellow. San Francisco Bay, November 22, 1872.

No. 104. Water-dog. Tributary of McCloud River, California, October 21, 1872.

No. 105. Salmon head. A fresh-run fish. Caught at Rio Vista, Sacramento River, November 21, 1872. Female. Rare at this season. Prime condition. Fat, silvery, and fine eating. Eggs very small. A true Sacramento River salmon. (See drawing.) The Sacramento salmon command this month the highest price in the market—25 cents, retail; wholesale, 18 cents—being more rare this month than at any time. There is another salmon (see No. 106) which is sold in the San Francisco market at this time, much inferior, and not commanding so high a price.

No. 106. Salmon head. November 21, 1872. Male.

Point Arena, Mendocino County, California. The fish referred to under the last number. It resembled in *form* the "fall run" of the McCloud males, in their best condition. It was, however, bright and silvery, with

scales very much as in a prime fish. The scales were smaller than those of the Sacramento salmon, and brushed off easily, as with a smolt. Both jaws had large teeth, but, as will be observed in the specimen, they are smaller than in the McCloud River males and are fitted loosely and flexibly into the jaw, as if set loosely in a piece of rubber lining. The teeth are, also, unlike the McCloud River fall run male, dark and dirty-looking. The teeth seemed to be in a transition state, and raised the question whether they were *coming* or *going*. A female of the same variety being found the next day with nearly ripe eggs, the inference seemed to be that the teeth of the fish must be *coming*. The milt of this fish was copious and prime. The eye, it will be observed, is larger than that of the Sacramento salmon. It also has a less forked tail. The fishermen say that it will not compare in table qualities with the true Sacramento salmon at this season. There were less fin-rays in the dorsal, pectoral, and anal fins than in the respective fins of Sacramento salmon. (See drawing.) There were grilse of this variety caught at the same place, in the San Francisco market to-day, bright silvery, and of very graceful form. These commanded a high price. (See drawing of No. 128.)

No. 107. Young cod-fishes. November 24, 1872. San Francisco Bay.

No. 108. Spawn of Point Arena salmon, showing stage of development. (See No. 106.) I learned from parties living at Eel River, north of Point Arena, that the salmon of that river come up to spawn in December and January, and if the rains are early, that the salmon spawn in those months in Eel River. It is possible that No. 106 was on his way to Eel River to spawn, as was also the female, having the eggs (No. 108). It is obvious from the advanced stage of the milt and eggs of these fish, that they were on their way to their spawning-grounds. If it is true that the Eel River salmon deposit their eggs in December and January, we have then seven months of the year now known to be salmon-spawning months, namely, July, August, September, October, November, December, and January.

No. 109. Pelican. *(Pelicanus fuscus.)* San Pedro brook. November 22, 1872. Contributed by J. Williamson.

No. 110. Dried salmon. This is a fair specimen of the dried salmon, which the McCloud River Indians live on chiefly through the winter. Most of the salmon used for drying are taken in August and September, when they are spawning or falling down the river exhausted, after spawning. They are then easily captured by spearing, or by traps. The spears are very long, and carefully made. The traps are merely baskets of bushes, placed at a fall or rapid, and winged on each side by a fence of stakes or bushes running at a slight angle *up* the river, so that the exhausted fish *coming down* the river, finally find their way into the basket and are there trapped. The McCloud Indians do not try to trap the fish coming *up the river*, but only those *going down*, which is just the contrary of the principle of the white man's trap and nets. The In-

dians, very singularly, *prefer* the exhausted and dying salmon for drying to the fresh and prime ones. As soon as a salmon is speared or taken from the trap it is opened—the spawn always being saved as a luxury—and split and hung on a bush or fence made for the purpose, in the open air. In the dry air of California, the drying process is sufficient to preserve them without salt. The Indians *never* use salt in preserving their salmon, and will not eat salt meat of any description. When the salmon are sufficiently dried, they are tied together in bundles, and packed away around the sides of the lodges. These specimens were presented by one of the McCloud chiefs, and, repulsive as they seem, they represent the main support of the Indians during the winter, and are highly valued by them.

No. 111. A deer-skin, tanned and dressed by the McCloud Indians. Used for making moccasins, and sometimes for clothes. Some of the deer-skins dressed by the McClouds are very white and soft. October, 1872.

No. 112. Deer-skin blanket. Prepared and sewed by the McCloud Indians. This is the common blanket of these Indians. October, 1872.

No 113. Heavy buck-skin blanket. Tanned by the McCloud Indians. Large and heavy skins like this are used alone, as blankets. This one is nearly as large as the two sewed together of the last specimen.

No. 114. Seeds, stalk, and leaf of plant used and highly valued by the Sacramento River Indians, for making thread and nets. It will be observed that it has a good fiber. Near Mount Shasta, October 10, 1872.

No. 115. White-perch. San Francisco Bay, December 2, 1872.

No. 116. Nuts of the "Digger" pine. Highly valued by the Indians as food. October, 1872.

No. 117. Soap-root. McCloud River, November, 1872. Used by Indians for making brushes.

No. 118. Stones of which arrow-heads are made by the McCloud Indians. McCloud River, October, 1872.

No. 119. Acorns and leaves of mountain live-oak. These acorns, together with the acorns of other oaks, form the next important staple of food to the dried salmon, among the McCloud Indians. The squaws gather them in great quantities, and make a kind of paste or soup of them, in which form they are eaten, almost exclusively. McCloud River, October 7, 1872. Contributed by B. B. Redding.

No. 120. Parasite on pine-tree. McCloud River, October 31, 1872. Contributed by J. G. Woodbury.

No. 121. Skate. San Francisco Bay, December 2, 1872.

No. 122. Skate. Bay of San Francisco, December 2, 1872.

No. 123. Young smelts. (*Atherinopsis californiensis ?*) Bay of San Francisco, December 3, 1872. These are universally sold in California for smelts, and the people generally suppose that they are smelts. Three specimens.

No. 124. Flounders. Three specimens. Bay of San Francisco, December 4, 1872.

No. 125. Soles. Three specimens. Bay of San Francisco, December 4, 1872.

No. 126. *Drawing.* A fine specimen of a Sacramento River salmon, in prime condition. This was a fresh-run fish, bright, plump, and silvery. Spawn very small. Caught at Rio Vista. Weight, 14 pounds. November 11, 1872. Winter run. These fish have just begun to ascend the Sacramento, this one being among the first that were caught this season, of the "winter run." Only a very few are taken as early as this; they are consequently rare in the markets and command a high price, (for California,) viz, 25 cents a pound, retail, and 18 cents a pound, wholesale. This is the beginning of a run of prime fish which does not slacken, nor much depreciate in quality, till June. (See Report on Sacramento Salmon.)

No. 127. *Drawing.* Male salmon. McCloud River, October, 1872. Foul, emaciated, and tail partly worn off. Compare with last drawing, No. 126.

No. 128. *Drawing* of grilse frequently seen in San Francisco market in November. This fish is taken at Point Arena, (a point on the coast of California, in Mendocino County,) and is sent to the San Francisco market when the Sacramento salmon are scarce. It is a beautiful fish, in form and general appearance, and commands a high price. They are all about the size of this specimen. They are bright and silvery. The scales are small and brush off very easily, as in salmon smolt. November 20, 1872.

No. 129. *Drawing.* Sacramento salmon, in prime condition. Female. Rio Vista, November 11, 1872. Weight, 18 pounds. "Winter run." Compare No. 126.

No. 130. Snake. Menlo Park station, Southern Pacific Railroad, San Mateo County. October, 1872. Contributed by Mr. Williamson.

No. 131. Salmon eggs. Dried by Indians for food. Esteemed a luxury. Presented by Indian chief. McCloud River, California, October, 1872.

No. 132. Arrows without points. Six specimens. McCloud Indians, McCloud River, California, October, 1872.

No. 133. Arrows, with stone points. McCloud Indians, McCloud River, California. Six specimens. October, 1872.

No. 134. Arrows, with steel points. Two specimens. Sacramento River Indians, (Upper Sacramento,) October, 1872.

No. 135. Arrows, with glass points. McCloud Indians, McCloud River, California, October, 1872. Six specimens.

No. 136. Arrows. Pitt River Indians. Pitt River, California, October, 1872.

No. 137. Indian bow, made by Con-choo-loo-la, chief of McCloud Indians, McCloud River, California. The bow is made of yew, and is cov-

ered on the back with salmon skin, which is prepared by a secret which the Indians will not disclose. The salmon skin imparts a wonderful elasticity to the bow, which will bend back, when it is unstrung, several years after it is made. Con-choo-loo-la is probably the last of the great chiefs of the McCloud Indians.

No. 138. Sprig of yew, from the wood of which the Indians make their bows. October 12, 1872. Upper Sacramento River.

No. 139. Salmon-eggs. McCloud River, California, September, 1873.

No. 140. Salmon-eggs, showing eye-spots. McCloud River, California, October, 1872.

No. 141. Young salmon, just hatched and hatching. McCloud River, California, October, 1872.

No. 142. *Shapaulle*, (Indian name.) Clear Lake, Lake County, California, February 5, 1873. Four specimens.

No. 143. Trout. Clear Lake, Lake County, California, February 5, 1873. Twenty-one specimens.

No. 144. *Chy?* (Indian name.) Clear Lake, Lake County, California, February 7, 1873.

No. 145. Male trout. Supposed to be two years old. Milt flowing. Cold Creek, Clear Lake, Lake County, California, February 8, 1873.

No. 146. Perch. Soda Bay, Clear Lake, California, January 25, 1873.

No. 147. ————? Clear Lake, California, February 8, 1873.

No. 148. *Shy*, (Indian name.) Clear Lake, California, February 10, 1873.

No. 149. Indian cake, made of the nuts of the *pepper-tree*. Used as food by the Clear Lake Indians. February 10, 1873.

No. 150. Spawn of mountain-trout, showing its stage of development in this variety. Cold Creek, Clear Lake, California, February 10, 1873.

No. 151 Salmon-trout. Kelsey Creek, Clear Lake, California. Girth, just in front of dorsal fin, 9 inches. Milt ripe. Formerly abundant, now becoming scarce.

Color.—Dark gray on back, shading off to lighter gray and pink, toward the lateral line. Gill-covers bright vermilion-red. Band of same color, about ¾ inch wide from gills to tail; brightest and broadest near the middle. Grayish-pink below red band. Abdomen white underneath, with blotches of grayish-pink. The fishermen say that this is the only variety of trout caught in or about the lake, besides the common mountain-trout. The body of the fish was deep and thin; and very thickly dotted above the lateral line and on the caudal, dorsal, and adipose fins with black spots. There were a very few black spots below the lateral line, chiefly near the head and tail. The pectoral, ventral, and anal fins were of a dark-gray color, and without spots.

No. 152. Sucker. Male. Clear Lake, California. Milt ripe. February 10, 1873. *Mem.*—Suckers and trout in this locality spawn at the same

time, while in New England they spawn at exactly opposite seasons of the year; the suckers in May and the trout in October.

No. 153. Skin of mud-hen. Clear Lake, California, February 13, 1873. Very abundant and very tame.

No. 154. Skin of white heron. Clear Lake, California, February 2, 1873. Not abundant.

No. 155. Water-lizard. February 10, 1873. Kelsey Creek, Lake County, California.

No. 156. Spawn of salmon-trout. Kelsey Creek, near Clear Lake, California, February 11, 1873.

No. 157. Pyloric appendages and milt-glands of No. 158.

No. 158. *Muraena.* (Italian name.) Farallone Indians, December 14, 1872. Spawn nearly ripe, and about the size of trout-spawn.

No. 159. Lake-trout or salmon-trout. Burtnett's mills, Kelsey Creek, Lake County, California, March, 1873. Contributed by J. G. Woodbury.

No. 160. *Shy* or *chy.* (Indian name.) Five specimens, (tag says six.) Cold Creek, Lake County, California, March 8, 1873. Contributed by J. G. Woodbury.

No. 161. *Nic-coosh*, or *mŭkh-ush.* Cold Creek, Lake County, California, March 8, 1873. By J. G. Woodbury.

Numbers 161 to 167 omitted.

No. 167. *Shapaulle.* Burtnett's mills, Kelsey Creek, Lake County, California, March 9, 1873. By J. G. Woodbury.

Nos. 168 to 208 omitted here; resumed further on.

No. 208. Trout. Independence Lake, on Sierra Nevadas, California, February 24, 1873.

No. 209. Same as No. 208.

Nos. 210 to 216. Chubs. Sacramento River, near mouth of San Joaquin, February 25, 1873.

Nos. 217 to 231. Perch. Sacramento River, Rio Vista, February 25, 1873.

Nos. 232 to 236. Hardheads. Sacramento River, near mouth of San Joaquin, February 25, 1873.

Nos. 237 to 243. Sacramento pike. Sacramento River, Rio Vista, February 25, 1873.

Nos. 244 to 250. Viviparous perch. Local name "sun-fish." Sacramento River, Rio Vista, February 26, 1873.

Nos. 251 to 262. Split-tails. Sacramento River, near Courtland, February 26, 1873.

Nos. 263, 264. Suckers. Sacramento River, Rio Vista, February 26, 1873.

Nos. 265 to 270. Herrings. Sacramento River, Rio Vista, February 26, 1873.

Nos. 271 to 273. Sturgeons. Sacramento River, Rio Vista, February 26, 1873. Saw one, February 27, at Rio Vista that weighed 200 pounds,

and was 9 feet long. Was told of one caught here that weighed 600 pounds.

No. 274. Herring. Sacramento River, Rio Vista, February 26, 1873.

No. 275. Lobster, (local name.) Sacramento river, Rio Vista, California, February 26, 1873.

No. 168. Small fish. Cold Creek, Lake County, California, February, 1873.

No. 169. Small fish. Cold Creek, Lake County, California, February, 1873.

No. 170. Two specimens from Chinese fish-market at San Francisco, February, 1873.

No. 171. Heads of male salmon; two specimens. Point Arena, California, December 1872.

No. 172. Yellow rock-fish. Bay of San Francisco, November 22, 1872.

No. 173. Small *Mur aena.* (See No. 158.) Farallone Islands, March 12, 1873.

No. 174. Red-headed woodpecker. McCloud River, California, November 1873.

No. 175. Blue-jay. McCloud River, November, 1873.

No. 176. Salmon-spawn, showing stage of development. Rio Vista, February 26, 1873.

No. 177. Salmon-spawn. Sacramento River, near Rio Vista, March 10, 1873.

No. 178. One bottle containing seven small fish, from Clear Lake, Lake County, California, February, 1873.

No. 179. Salmon-spawn. Near Rio Vista, December, 1873.

No. 180. Salmon-spawn. Near Rio Vista, January 25, 1873.

No. 181. Spawn of lake-trout. Clear Lake, February, 1873.

No. 182. Young trout. Spawned and bred artificially from parents caught in the San Andreas reservoir, near San Francisco. (See No. 8 of first catalogue.) Three specimens.

No. 183. Small water-dogs. McCloud River, California, November, 1872. The bottle also contains two 1000-legged worms, and an unknown insect.

No. 184. Supposed to be the "steamboat-bug." Sereno Lake, Sierra Nevada Mountains, California, altitude 7,000 feet, November 9, 1872. This insect was found swimming in the water, under ice an inch thick or more. It seemed, says Mr. Redding, to gather water within its body by some process, and to propel itself along by ejecting it again from behind. It was observed some time in order that the pumping process of the insect might be well ascertained. Contributed by Hon. B. B. Redding.

No. 185. Twig of pepper-tree. See No. 149. Clear Lake, Lake County, California, February, 1873.

VII.—NOTES ON THE SALMON OF THE MIRAMICHI RIVER.

By Livingston Stone.

The salmon begin to arrive in the Miramichi River about the 10th of June. There is, I believe, only one or two days difference between the time of their arrival at the mouth of the river and at the head of tide-water, about sixty miles above. The salmon continue to run from the 10th of June to the spawning-season, (the middle of October,) and there is said to be one run after that, called by the fishermen the November run.

The flesh of the June runs of fish is very much the best; very fat, rich, and delicious. The quality of their flesh deteriorates steadily from this month till they spawn; but the size of the later runs of fish seem to be about the same, except in the November salmon, which are smaller. This November run does not, I think, make its appearance every year, but usually. These fish seem to be in a great hurry, and make a rush for the spawning-beds without any of the delays on the way up which are noticed in the earlier runs.

In June the salmon are all, males and females, bright and silvery, with small, gentle-looking heads, and plump and gracefully-formed bodies. At this time males and females look alike, and can hardly be distinguished. As the spawning-season approaches, both sexes, but especially the males, change their silvery coat and put on gorgeous colors; the spots varying from a pale blue and straw color in some fish to a deep red, purple, and gold in others. Their colors are mingled with all the other tints of the rainbow. Nothing can exceed the beauty of coloring of some of the handsomest male fish at the height of the spawning-season. The head of the male, however, has changed for the worse. It has grown long and low: the ugly-looking tush of the lower jaw has protruded its full length, and the whole expression of his head and eye is malicious and savage in the extreme. We found a few exceptional salmon of both sexes, of a dark silvery hue, without spots. They were usually the most difficult to handle; next to these in this respect came the deeply-colored males. The milder-colored fish were the easiest to manage. The distinction of the sexes was very marked at this time. The ugly head of the male and the swollen ovaries of the female furnished unmistakable indications of the respective sexes.

The salmon in the Miramichi begin to spawn about the 15th of October, or, according to the Indians' almanac, when the juniper turns red. The spawning-season seems to be quite short, as the fish were all through spawning in the river in 1868, (except the November ones,) on the 20th of October. On that day and the three succeeding days I swept the

river thoroughly, over nine miles of spawning-ground, with a very long sweep-seine, and of all the salmon we caught, which were a great many, there were only two which had not spawned, and one of these had been injured by a spear-wound. The juniper having now faded, the Indian chief pointed to it again, and said, "Salmon all spawned; no more salmon spawn this year." This was not true, however, of our captured salmon in the ponds, two of which continued to hold their eggs till the 15th of November. Floating ice made its appearance in the river in large quantities as early as the 20th of October, and by the first week in November the river was entirely closed, and fishing through the ice began. The salmon of the Miramichi average about nine or ten pounds in weight. The largest two which we caught weighed 30 pounds each. One was a male, the other a female. As a rule the males were the largest. There are no spring runs of salmon in the Miramichi that I am aware of; but in the Saint John a variety of salmon comes up the river in the spring, and spawns in the spring. They are always expected and regularly fished for at this time. They are a little smaller than the fall fish of the Saint John, and weigh, I believe, eight or nine pounds each. The number of these fish is quite limited.

The salmon of the Restigouche are larger than those of the Miramichi, averaging perhaps twelve pounds. Very large salmon, weighing fifty or sixty pounds, are caught in the Restigouche.

Opinion is very much divided among the fishermen as to the migratory movements of the Miramichi salmon. Some say that there are salmon that go to the sea twice a year; others that they come from the sea but once in two years. It is certain that some remain through the winter in the river, and that there are salmon going down the river in the spring. It is generally agreed that, as a rule, they spawn in October; that the young are hatched in the spring; that they remain in the river until the next spring or succeeding summer, when they put on the smolt-coat and go to the sea. They are then about six inches long. It is thought that they return to the river the same fall as grilse, weighing from three to eight pounds. This, I think, is the common opinion, but I do not consider that the belief is by any means fully established. I saw thousands of smolts going down the river in July, which I cannot believe were the grilse that we caught the following fall. Is it not possible that some of the smolts remain in the ocean till the next year? One-half the parrs of each year, without doubt, remain two years as parrs in fresh water before going to the sea.

FRAGMENTARY NOTES.

Salmon are very abundant in the Miramichi and in all the rivers east of it. Messrs. Stone and Goodfellow shipped 60,000 pounds of fresh salmon from this river to Boston and New York from June 10 to July 10, 1869. I never saw a fisherman who had found food in the stomachs of the salmon taken in the river. Our salmon in the artificial breeding-

pond had no food while in confinement, which, in some instances, lasted from the 1st of September to the middle of November, two months and a half. Of the fall runs of fish from tide-water to the spawning-beds the most numerous were between September 27 and October 4. We twice caught a hundred salmon a night at this time in our stake-net set across the river.

The eggs of these salmon vary very much in size, some not being larger than small trout-eggs, others being a third larger than the average size of salmon-eggs. The fishermen claim that they can distinguish a Restigouche salmon from a Miramichi salmon, when one of the former straysinte the Miramichi.

In September large numbers of salmon lie in the holes a few miles below the spawning-beds, waiting for a rise of water. When the rain comes and the water rises, they rush up over the rapids to their spawning-grounds in great numbers. The salmon on the Miramichi were caught in 1868 by the whites, mostly in stake-nets running out from the shore about 250 feet. The Indians speared them. We found good and abundant milt in the male grilse. I never saw a female grilse in the Miramichi. If I recollect rightly, I have seen milt in a salmon-parr.

The habits of these salmon about spawning, and in general, resemble those of eastern salmon elsewhere. The number of eggs in a fish is about 1,000 to the pound. See Canadian fishery reports for information about modes of capture, &c, &c.

VIII.—THE SALMONIDÆ OF EASTERN MAINE, NEW BRUNSWICK, AND NOVA SCOTIA.

BY CHARLES LANMAN.

NOTE.—I am indebted to Mr. Charles Lanman, the well-known artist, traveler, and sportsman, for accounts of the habits of the salmon, trout, togue, white-fish, capeton, smelt, shad, and gaspereau, or alewife, of Eastern Maine, New Brunswick, and Nova Scotia, based partly on the inquiries of Mr. Moses H. Perley, but supplemented and verified by his own experience. Having spent many summers in the region referred to, and always with his attention directed to the habits of the species, the present article, hitherto unpublished, will be found to embody some interesting additions to our knowledge. It is proper to state that it was written many years ago, and therefore cannot include the more recent additions to our knowledge of the same species.

Notices by Mr. Lanman of the white-fish and the shad will be found in their appropriate places.

S. F. BAIRD.

1.—THE BROOK-TROUT, (*Salmo fontinalis.*)

Nearly every lake and stream in New Brunswick and Nova Scotia is furnished with a greater or less number of this species of the salmon family. It is taken of all sizes, from six to twenty inches, and is so well known as scarcely to need a description. Its principal characteristics are the vermilion dots and larger yellow spots in the vicinity of the lateral line, and the tri-colored fins, these being blackish on their edges, broadly bordered with white, and the rest scarlet.

The brook-trout is a migratory fish; when in its power, it invariably descends to the sea, and returns to perpetuate its species by depositing its spawn in the clearest, coolest, and most limpid waters it can find. During the last thirty years, the writer has caught many thousands of these trout, in numerous rivers, lakes, streams and estuaries, in the lower provinces and in Maine, and can safely say, after close and attentive examination, that he has never seen but one species of the brook-trout, whatever naturalists may say to the contrary.

Various causes have been assigned for the great variety in the color of the brook-trout. One great cause is the difference of food; such as live upon fresh-water shrimps and other crustacea, are the brightest; those which feed upon May-flies and other common aquatic insects are the next; and those which feed upon worms are the dullest and darkest of all.

The color and brilliancy of the water has, also, a very material effect upon the color and appearance of *Salmo fontinalis*. Professor Agassiz has made some very curious experiments with respect to the colors of fishes, especially the *Salmonidæ;* and he has ascertained beyond a doubt not only that trout of different neighboring waters are affected by the color and quality of the water, but that trout of the same river vary in color, accordingly as they haunt the shady or sunny side of the stream.

The fish of streams rushing rapidly over pebbly beds are superior, both in appearance and quality, to those of ponds, or semi-stagnant brooks. But this may arise, not so much from any particular components of the waters themselves, as from the fact that rapidly running and falling water is more highly aerated, the atmosphere being more freely intermingled with it, and therefore more conducive to the health and condition of all that inhabit it.

There is no sportsman actuated by the true animus of the pursuit, who would not prefer basketing a few brace of good trout, to taking a cart-load of the coarser and less game denizens of the water. His wariness, his timidity, his extreme cunning, the impossibility of taking him in clear and much-fished waters, except with the slenderest and most delicate tackle; his boldness and vigor after being hooked, and his excellence on the table, place him, without dispute, next to the salmon alone, as the first of fresh-water fishes. The pursuit of him leads into the loveliest scenery of the land; and the season at which he is fished for is the most delightful portion of the year.

The brook-trout rarely exceeds three pounds in weight, and no well-authenticated case is on record of one of the species having reached the weight of six pounds, in these lower provinces.

2.—THE GREAT GRAY-TROUT OR TOGUE, (*Salmo toma.*)

This fish is found in all the large lakes of New Brunswick, and in very many of those in Maine, but it is believed not to exist in the lakes of Nova Scotia. It is called by the lumbermen the *togue;* the Indians designate it by a name equivalent to "fresh-water cod." It is found in great numbers and of large size in the Eagle Lakes, at the head of Fish River; in the St. Francis Lakes, from which flows the river of that name; and in the Matapediac Lake, which discharges itself into the Restigouche, and in the Mirimichi Lake, at the head of that river. In Lake Temiscouata, this fish has been taken of the weight of 21 pounds. It is there called the *tuladi.* It is often taken of the weight of 12 pounds, and upward, in the Cheputnecticook Lakes, at the head of the eastern branch of the Saint Croix. One sporting friend informs the writer that he caught two of these fish on the Saint Croix Grand Lake, one of which weighed 8 pounds, and the other 13 pounds, but that he saw one taken by a night-line which weighed 25 pounds. Another sporting friend, a resident of New York, informs the writer that he has visited the lakes on the western branch of the Saint Croix,

where he caught several togue, weighing from 4 pounds upward. The largest he caught measured 29 inches in length, but weighed 8 pounds only, not being in good condition.

It has been found of late years that this species of fish exists in considerable numbers in Loch Lomond, twelve miles from the city of Saint John; and they have, in consequence, been sought after by sportsmen, who take them from a boat, by trolling over the deepest portions of the loch.

A specimen of this fish, taken in Loch Lomond in 1848, was said to correspond exactly with the fish described by Mr. Yarrell as *Salmo ferox*, the great gray-trout of Loch Awe.

This fish is taken from a boat rowed gently through the water; the bait, a small fish guarded by several good-sized hooks. They are extremely voracious, and having seized the bait, will allow themselves to be dragged by the teeth for forty or fifty yards, and when accidentally freed, will again immediately seize it. The young fish, up to 3 pounds weight, rise freely at the usual trout-flies; the writer has often taken them up to that weight by fly-fishing, but never larger.

When in perfect season and full-grown, it is a handsome fish, though the head is too large and long to be in accordance with perfect ideas of symmetry in a trout. The colors are deep purplish-brown on the upper parts, changing into reddish-gray, and thence into fine orange-yellow on the breast and belly. The body is covered with markings of different sizes, varying in number in different individuals. Each spot is surrounded by a pale ring, which sometimes assumes a reddish hue; the spots become more distant from each other as they descend below the lateral line, and the lower parts of the fish are spotless. The fins are of a rich yellowish-green color, darker toward their extremities. The tail is remarkable for it breadth and consequent power. The flavor of this fish is coarse and indifferent; the flesh is of an orange-yellow, not the rich salmon-color of the common-trout, in good condition. The stomach is very capacious, and generally found gorged with fish; it is very voracious.

3.—THE WHITE SEA-TROUT, (*Salmo immaculatus.*)

This beautiful trout abounds in the Gulf of St. Lawrence; it is found on the northern shores of New Brunswick and in the estuaries of those rivers of New Brunswick and Nova Scotia which flow into the gulf and the Strait of Canso, early in June. It is caught in nets at the Magdalen Islands in summer, and salted for export. Many sportsmen resort annually to river Philip in Nova Scotia, during the month of June, to fish for these sea-trout, which enter the estuary of the river at that season. No specimen of this fish has yet been seen in the Bay of Fundy, which it is supposed not to frequent.

The flesh of the salmon-trout is of a brilliant pink-color, and most excellent; its exceeding fatness early in the season, when it first enters

the mixed water of the estuaries, is such, that it can be preserved fresh but a very short time. The body of the fish is rather deep for its length; the lateral line is very nearly straight, passing along the middle of the body, the scales adhering closely. The upper part of the head and body, a rich sea-green color; the lower part of the sides and belly, a brilliant silvery-white; the fins white, except the dorsal, which is nearly the color of the back.

Sir William Jardine, in speaking of this fish, accurately describes its habits, as observed in New Brunswick. He says: "In approaching the entrance of rivers, or in seeking out as it were some one they preferred, shoals of these fish may be seen coasting the bays and harbors, leaping and sporting in great numbers, from about one pound to three or four pounds in weight; and in some of the smaller bays, the shoal could be traced several times circling it, and apparently feeding."

Mr. H. Robinson Storer, during his visit to Labrador in 1849, met with a single specimen of the salmon-trout of the gulf at Red Bay, in the Straits of Belle Isle, and designated it *Salmo immaculatus*. The scientific description he gives is accurately that of the present, and is as follows:

"*Color.*—Silvery on sides and abdomen; darker on back; no spots.

"*Description.*—Length of head about one-sixth length of body; depth of head, two-thirds its length; greatest depth of body directly in front of dorsal fin, equal to length of head. Upper jaw the longer. Jaws with numerous sharp incurved teeth. Eyes laterally elongated; their diameter one-third the distance between them. Opercles rounded posteriorly; lower portion of operculum naked, marked with concentric striæ; preopercle larger than in the *fontinalis;* scales larger than those of the *fontinalis.* Lateral line commences back of superior angle of opercle, and, assuming the curve of the body, is lost at the commencement of the caudal rays. The first dorsal fin commences just anterior to median line; is nearly quadrangular. Adipose fin situated at a distance back of the first dorsal, little less than one-half the length of the fish. Pectorals just beneath posterior angle of operculum; their length three-fifths that of the head. Ventrals just beneath posterior portion of first dorsal; the plates at their base very large. The anal is situated at a distance back of the ventrals just equal to length of head, and terminates directly beneath the adipose fin; of the form of first dorsal. Caudal deeply forked; its length equal to greater depth of body. Dorsal, 9; pectorals, 13; ventrals, 9; anal, 11; caudal, 30; length, 13½ inches."

To the epicure a fresh-caught salmon-trout of the Gulf of Saint Lawrence, especially early in the season, will always afford a rich treat. The sportsman will find it a thoroughly game-fish, rising well at a brilliant fly of scarlet ibis and gold, and affording sport second only to salmon-fishing. The writer has caught this fish with the scarlet ibis fly in the break of the surf, at the entrance of Saint Peter's Bay, on the north side of Prince Edward Island, of the weight of 5 pounds; but

the most sporting fishing is from a boat, under easy sail, with a "mackerel breeze," and oftentimes a heavy "ground-swell." The fly skips from wave to wave, at the end of thirty yards of line, and there should be at least seventy yards more on the reel. It is truly splendid sport, as strong fish will oftentimes make a long run, and give a sharp chase down the wind.

At Gaysboro' and Crow Harbor, in the Strait of Canso, there is excellent sea-trout fishing at the end of June, as also in the great Bras d'Or Lake, within the island of Cape Breton. The largest sea-trout rarely exceed seven pounds' weight; these are taken around the Magdalen Islands, and in the estuaries of all the rivers of the Labrador coast, from Mingan to the northern end of the Straits of Belle Isle.

4.—THE SALMON, (*Salmo satar.*)

The noble salmon, which honest Isaac Walton justly calls "the king of fresh-water fish," is so well known in the North American colonies as to need no description.

As in Western Europe, so in Eastern America, it is generally believed that there is but one species—*Salmo salar—the salmon;* and that they are the same in both countries.

The salmon enters the rivers of Nova Scotia during the latter part of April. Those rivers of New Brunswick which fall into the Bay of Fundy, the salmon enters at the latter part of May, while it seldom enters those falling into the Gulf of Saint Lawrence until the month of June.

The female salmon first enters the rivers; the male fish follows about a month later than the female; and lastly, come the grilse, or young salmon, which continue to ascend the rivers during July and August.

Salmon swim with great rapidity—shoot up the most oblique and glancing rapids with the velocity of an arrow, and frequently leap falls ten and twelve feet in height. It is believed that the utmost limit of perpendicular height which a salmon can attain in leaping is fourteen feet; but their perseverance is remarkable, for, although they may fail, time after time, yet, after remaining quiescent for a few moments to recruit their strength, they renew their efforts and generally succeed; but, it is said, they sometimes kill themselves by the violence of those efforts.

In New Brunswick the salmon seldom deposits its spawn until the middle of October. The fish that have spawned generally return to the sea before the rivers become ice-bound in December, but many remain in the fresh water all winter, and go down to the sea at the breaking up of the ice in spring.

Before entering the rivers, they live awhile in the brackish water of the tide-ways, as they do also when they descend to the sea, to render the change from one to the other less abrupt, and to rid themselves of

certain parasitical animals which attach to them when they remain long either in fresh water or in salt, as the case may be.

The spawn is not deposited until the water is greatly below its summer temperature. Professor Agassiz stated personally to the writer, that 42° of Fahrenheit's thermometer, or 10° above the freezing-point, was the temperature at which salmon usually cast their ova. It is absolutely necessary that the water should be aerated, or highly supplied with oxygen; hence the salmon resort to shallow, pure water, and swiftly-running streams, the rapidity and frequent falls in which impart purity and vitality, by mingling their waters with the atmosphere.

The food of the salmon, previous to its quitting the salt water, consists of the eggs of *Echinodermata* and *Crustacea*, this rich aliment giving the color and flavor for which its flesh is so highly prized. This is sustained by the observations of Professor Agassiz, who states that the most beautiful salmon-trout are found in waters which abound in *Crustacea*, direct experiments having shown to his satisfaction that the intensity of the red colors of their flesh depends upon the quantity of *Gammaridæ* which they have devoured.

Fly-fishing for salmon in Nova Scotia and New Brunswick increases annually, as the various rivers become known, and the proper localities and seasons are ascertained. The two most noted rivers in Nova Scotia are the Gold River, which flows into the Atlantic west of Halifax, and Saint Mary's River, to the eastward of that port. In New Brunswick the best rivers are the Southwest Miramichi, from Boiestown upward, and the Nepisiguit River, which flows into the Bay of Chaleur, at Bathurst. It is known, however, that there is good salmon-fishing in several other rivers of both provinces, while it is believed that there are many rivers, especially in the northern part of New Brunswick, yet untried, which, if visited by experienced sportsmen, not afraid of rough work at the outset, would afford good sport and heavy fish during the whole of every season.

5.—THE AMERICAN SMELT, (*Osmerus mordax.*)

This beautiful and savory fish abounds in New Brunswick and Nova Scotia; it is sometimes taken a foot in length, but its average size is about 5 or 6 inches. Very soon after the rivers are freed in spring from their icy fetters, the smelts rush in to the smaller streams, in countless thousands, and are then taken with the most wasteful profusion. The popular name of smelt is given to this fish from its peculiar smell, which resembles that of cucumbers; this is strongest when the fish is first taken, but it may be perceived by raising the gill-covers, after the fish has been some time out of the water.

On the gulf coast of New Brunswick large quantities of the smelt are used every season as manure. At Miscou and other fishing stations in the Bay of Chaleur it is taken in great numbers, with the seine, and

used as bait for cod. The endless abundance of the smelt causes it to be less valued as food than it really deserves.

The smelt feed largely on the shrimp. They bite readily at the hook, baited with a piece of any of the crustaceous animals, and affords endless sport to young anglers. They are also caught in thousands by fishing through holes cut in the ice, during winter, and are then greatly prized. The writer has frequently taken the smelt with a small scarlet fly, while fishing for sea-trout in the Gulf of Saint Lawrence, and they would undoubtedly furnish very pretty light sport, if other and nobler game did not exist in the same locality.

6.—THE CAPELIN, (*Mallotus villosus.*)

This, the smallest species of the salmon family, inhabits the northern seas only, never ranging farther south than the shores of New Brunswick. It is very nearly allied to the genus *Osmerus.* The capelin is from 4 to 7 inches in length, the back and top of the head a dull leek-green, with bright green and yellow reflections, when moved in the light; sides and belly covered with delicate and very bright silvery scales, which are dotted on the margins with black specks; the back covered with small, smooth grains, like shagreen. The manner in which the capelin deposits its spawn is one of the most curious circumstances attending its natural history. The male fishes are somewhat larger than the female, and are provided with a sort of ridge projecting on each side of their back-bones, similar to the eaves of a house, in which the female capelin is deficient. The latter, on approaching the beach to deposit its spawn, is attended by two male fishes, who huddle the female between them, until the whole body is concealed under the projecting ridges, and her head only is visible. In this position all three run together, with great swiftness, upon the sands, when the males, by some inherent imperceptible power, compress the body of the female, between their own, so as to expel the spawn from the orifice and the tail. Having thus accomplished its delivery, the three capelins separate, and paddling with their whole force through the shallow water of the beach, generally succeed in regaining once more the bosom of the deep; although many fail to do so, and are cast upon the shore, especially if the surf be at all heavy. Like the common smelt, the capelin possesses the cucumber smell; but it differs from the smelt in never entering fresh-water streams.

As an article of bait for cod, and other fish of that class, the capelin is of much importance; wherever abundant, the cod-fishing is excellent. It has been found as far north in the Arctic regions as man has yet penetrated; and it forms so important an article of food in Greenland, that it has been termed the daily bread of the natives. In New Foundland, it is dried in large quantities, and exported to London, where it is sold principally in the oyster-shops.

IX.—ON THE SALMON OF EASTERN NORTH AMERICA, AND ITS ARTIFICAL CULTURE.

By Charles G. Atkins.

A.—SALMON-CULTURE FROM IMPORTED SPAWN.

1.—THE APPOINTMENT OF COMMISSIONERS, AND THEIR PRELIMINARY WORK.

The extended efforts now making in the United States to restore and improve the river and inland fisheries had their origin in New Hampshire in 1864. The late Hon. Henry A. Bellows, of Concord, secured the adoption, by the legislature of that year, of resolutions providing for the appointment of commissioners to investigate the question of restoring the migratory fishes to the Merrimac and Connecticut Rivers, and requesting the States bordering on those rivers to pursue the same investigation. New Hampshire appointed H. A. Bellows and W. A. Sanborn. The other States responded favorably; Massachusetts appointing, in 1865, Theodore Lyman and Alfred A. Reed; Vermont, in the fall of the same year, appointing Albert D. Hager and Charles Barrett; Connecticut, in 1866, appointing F. W. Russell and Henry C. Robinson. The principal impediments in the way of the ascent of the rivers in question by fish lying in Massachusetts, the burden of the investigation naturally fell upon her commissioners, who thoroughly examined the subject in all its bearings, and in their report discussed in a lucid manner the habits and wants of the fish, the character of the impediments, and the means of overcoming them; and pronounced the project feasible. The commissioners of the other States made similar reports, and the several legislatures continued the commissions, giving them authority to institute measures for the realization of the project. A year later the State of Maine appointed commissioners for a similar purpose, and more recently the same action was taken in New York, Rhode Island, New Jersey, and Michigan. The powers and duties of the commissioners in the States that led the movement have been somewhat enlarged, but the main purpose of their first appointment, the restoration of migratory fishes, such as shad, salmon and alewives, to the rivers they formerly frequented has been steadily kept in view.

From the beginning the commissioners found serious difficulties in the way; not only were lofty dams to be furnished with ways whereby great shoals of fish could and would surmount them, but in many cases,

and as regards salmon in most cases, the fishes themselves were wanting, having been utterly exterminated, and not to be had again without bringing a new stock from abroad. Nor would it do to bring adult salmon and place them in the rivers to be restocked, for they could not be relied upon to remain and breed there. If, however, the salmon should be reared there from infancy they would return when grown to lay their eggs in the same streams. To get the young fish the most feasible mode was to bring the spawn and hatch them. One of the very first things the commissioners did, therefore, was to cast about them for a supply of spawn.

2.—OPERATIONS IN 1866.

In the fall of 1866 the commissioners of fisheries of the State of New Hampshire dispatched Dr. W. W. Fletcher, of Concord, to New Brunswick, to obtain salmon-spawn for use in stocking the Merrimac River. He obtained permission from the government of the province to take salmon for his purpose at the spawning season on the Miramichi River, and succeeded in taking with the spear salmon enough to yield about 70,000 eggs. Great uncertainty existing as to the best mode of packing eggs for transportation, Dr. Fletcher packed his in several modes. Some fifteen or twenty thousand were packed in moss in champagne-baskets, and these alone were transported to New Hampshire in safety. A small part of them, two or three hundred, were hatched in a spring near Concord, where their development could be observed, and 90 per cent. of them hatched. The remainder of the lot was planted at once in artificially-prepared beds in suitable gravelly rapids in the Pemigewassett River, a tributary of the Merrimac, where they were left to take their chances of hatching. The following autumn Dr. Fletcher discovered several young salmon (parrs) in that vicinity, a satisfactory proof that a certain degree of success attended the hatching of the eggs.

3.—OPERATIONS IN 1867.

This year Dr. Fletcher was again dispatched by the New Hampshire commissioners to the Miramichi River, and obtained again about 70,000 salmon-eggs, nearly all of which were transported in safety to New Hampshire. About half of these were placed in charge of Livingston Stone, of Charlestown, N. H., to be hatched out for the benefit of the Connecticut River; the other half were sent to Robinson and Hoyt, at Meredith, N. H., to be hatched out for the Merrimac. About 5,000 were hatched in each place,*† the remainder failing by reason of non-fecundation.* Of the fry hatched at Charlestown nearly all were lost during the hot days of July, 1868.* Of those hatched at Meredith but very few were lost, and the following spring they were turned into the Pemigewassett, a few miles above Livermore Falls.†

* Report of the [Massachusetts] Commissioners of Fisheries for the year ending January 1, 1869.

† Letter of Robinson & Hoyt.

4.—OPERATIONS IN 1868.

This year Mr. Livingston Stone, under the patronage of the States of Massachusetts and New Hampshire, established a salmon-breeding establishment on the northwest branch of the Miramichi River, eight miles above Newcastle, on the farm of Mr. Joseph Goodfellow. A hatching-house, 100 feet by 27, was built, and a pond with an area of about an acre. A large spring and a spring-brook supplied them with water. The Canadian department of marine and fisheries granted a permit to carry on the enterprise, including the privilege of taking the fish and spawn at the breeding season, under certain conditions, the main one being that half of the eggs obtained should be hatched out on the Miramichi and the young fish turned into its waters at the proper time. In September Mr. Stone, through his employés, began the work of catching the parent fish. A stake-net was set in the river, and the salmon caught in it each day were placed in the pond. Owing to a misunderstanding of some sort, this work was interrupted by the local fishery officers, who seized successively seven or eight nets. For this reason a sufficient number of salmon were not caught, although it appears that on two occasions, between September 27 and October 4, one hundred salmon were taken in the nets in a single night. The collection of salmon continued until October 15. At this date the taking of spawn from fish in the pond began. On the 15th, 16th, and 17th twenty-eight females were stripped, yielding 226,500 eggs. After this there were stripped, from among the salmon already impounded, eighteen females, and from the river two more were taken, ripe and full, after the 20th of October. Thus the whole number of females stripped was forty-eight, and the yield of eggs was 443,900.*

These were all deposited in the hatching-house, and there remained until the appearance of the eye-spots. The loss meanwhile, from all causes, amounted to 87,900. The remainder, 356,000 eggs, were divided into two equal portions; one was left in the troughs to hatch, and the other packed up and transported to New Hampshire. After Mr. Stone's departure with the transported eggs, the establishment was left in charge of Mr. Joseph R. Goodfellow, the owner of the farm on which it was situated. According to Mr. Stone's figures, there were 178,000 eggs left there. From the best information at my command it appears that they all came to naught. Late in July, 1869, the establishment was visited by Mr. Samuel Wilmot, the superintendent of the salmon-breeding establishment at Newcastle, Ontario, who found the young fry still in the troughs. He states that they did not exceed 10,000 in number, and that they were in a very unhealthy condition.† I infer that this was all that remained out of the whole lot of eggs. A few days later Mr. Goodfellow turned out all the young salmon remain-

* Domesticated Trout, by Livingston Stone, A. M., p. 300.

† Annual Report of the Department of Marine and Fisheries, [Canada,] for the year ending 30th June, 1869, p, 107.

ing into the tidal part of the Miramichi River, where it is possible that they all perished.*

Mr. Stone's share of the eggs was packed up in moss and successfully transported to his breeding-works at Charlestown, N. H. The Massachusetts and New Hampshire commissioners, jointly, purchased 100,000 of them, to be devoted to the restocking of the Merrimac River, and these were sent to the hatching-works of Robinson & Hoyt, of Meredith, N. H.; 7,600 were sent to the Massachusetts State hatching-house at East Wareham; small lots to Winchester and West Barnstable, Mass.; to the Poquonnoc Fish Company of Connecticut, and the South Side Club of New York.

The exact number delivered to Messrs. Robinson & Hoyt was, according to Mr. Stone's estimate, 99,400. From these were picked out 53,123 eggs that showed no sign of fecundation.† The rate of fecundation was therefore about 46 per cent. of those transported. Of the fecundated eggs only 329 died during incubation, leaving 45,948 that hatched. The first fish came out January 6; the hatching culminated on the 20th, and was concluded February 1. The incubation was conducted in a graveled trough with a gentle current of water an inch deep. After hatching, they were placed, at the suggestion of the commissioners owning them, in a wooden tank 60 feet long, 4 feet wide, and from 1 to 2 feet deep, and were fed by placing finely-chopped food in a stream of water which was led into a spout with a perforated bottom that ran the whole length of the tank, the food being thus very evenly distributed. The conditions, however, failed to meet the wants of the fish, and during the summer fully three-quarters of them died.† In October a freshet carried the greater portion of those alive into a trout-pond, from which, probably, few ever escaped. The remainder were kept until the following summer, when they were set at liberty in the Pemigewassett River, having meanwhile become reduced in number to about 1,000.‡

Among the eggs carried to Massachusetts there was about the same ratio of fecundation. Of the 7,600 sent to the State hatching-house 4,280 proved defective, the most of them being infecund; and the number hatched out was 3,320. During the season these got mixed with a lot of Schoodic salmon of the same age, and it was found impracticable to sort them out. They were left together until the close of the season. Until the 1st of September they were kept in a hatching-trough, where the water was only 4 inches deep. During this time, though perfectly healthy and feeding heartily, they grew very slowly, attaining a length of only an inch and a half. Most of them were then transferred to a long trench, with a foot of water and plenty of room,

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* Annual Report of the [Canadian] Department of Marine and Fisheries for the year ending 30th June, 1869, p. 107.

† Letter of Robinson & Hoyt.

‡ Fifth Annual Report of the [Massachusetts] Commissioners on Inland Fisheries, January, 1871, p. 11.

and here, by the end of October, a large part of them attained a length of 3 inches. They were now about nine months old, and only 8 per cent. of them had been lost since hatching. At West Barnstable Messrs. Dexter, Coolidge & Bacon hatched out, for the State, 1,700 salmon, and kept them through the season, losing, between the middle of May and the last of November, only 4 per cent. of this number. The largest of them were then 5 inches long, a remarkable growth, which is attributed in part to their having occupied during the summer and fall a pond 2 feet deep. About an equal number of salmon (1,700) was hatched by Mr. E. A. Brackett, of Winchester.* The final distribution of the several lots of young salmon hatched in Massachusetts from this stock of eggs is, as far as I have been able to trace it, as follows: 700, raised at Winchester, in the Mystic River; 1,500, raised at West Barnstable, in one of the streams of Cape Cod; the brood at East Wareham, "in suitable waters."†

Of the salmon hatched by Mr. Stone himself, 2,000 were sold in the spring of 1869 to the Poquonnoc Fish Company of Connecticut. A few of them were kept in the trout-ponds until the spring of 1870, and the rest were turned into Great Brook, a small stream tributary to Long Island Sound, about three miles east of New London.* Of those retained in the ponds a few became smolts in 1870, and all were turned into the same brook to take their chances. Ninety yearling salmon from the same stock of eggs were this year purchased of Mr. Stone and placed in the same waters.‡

Another lot of fry from Mr. Stone's hatching-works were sold to Vermont in 1869, and placed by her commissioners in small tributaries of the Winooski River, near Montpelier, and in West River, at Weston. Some observations made on the fortunes that attended these fish gave results that are worth recording as illustrating the dangers to which young fish are exposed. Care was taken to select streams in which there were no fish but very small ones; yet it was but a short time before quite a number of small dace were discovered in the midst of the young salmon; the former were very active, the latter sluggish and bewildered, and making no effort to escape. Within half an hour after placing some salmon in a stream near Montpelier, a dace only 2 or 3 inches long was caught, and found to have swallowed four young salmon. Some of this brood escaped destruction, however, and were seen late in the summer and fall of the same year.§

Of the disposition made of the remainder of Mr. Stone's stock of eggs, I have no definite information; but for the sake of an approximate estimate of the total number of young salmon turned into the rivers as

* Report of the [Massachusetts] Commissioners of Fisheries for the year ending January 1, 1870, pp. 31, 32.

† Fifth Annual Report of the [Massachusetts] Commissioners on Inland Fisheries, January, 1871, pp. 11, 15.

‡ W. Clift, MSS.

§ Letter of Prof. A. D. Hager.

the result of the expedition, I will assume that all of the 78,000 eggs remaining after the deposit of 100,000 at Meredith did as well as those sent to Massachusetts, of which not far from 40 per cent. reached the end of their artificial nurture and were set free. In this way we obtain 31,200 as the number of free young salmon. Adding to this the number that came from the Meredith lot of eggs, 1,000, we have a total of 32,200 young salmon as the net result of the expedition.

5.—OPERATIONS IN 1869.

Owing to causes that it is unnecessary for me to discuss, Mr. Stone was obliged to abandon his enterprise on the Miramichi. Mr. Joseph R. Goodfellow, however, collected in October, 1869, a lot of eggs, and sold them to the commissioners of Vermont. They were deposited in the hatching-troughs between the 20th and 24th of October, and remained there until the first week in December. They were then packed up in moss, in baskets, and sent to Vermont. After a series of mishaps, which prolonged the period occupied in transportation to three weeks and four days, they reached Chester, Vt., and were placed in Professor Hager's hatching-troughs. The whole number of eggs was 50,000, and the loss in transportation and incubation was estimated at 20 per cent., leaving 40,000 young fry, all of which hatched between the 1st and 15th of February. The water had a temperature of 45° F., and was so pure that no filtering was necessary. Not over 100 died during the absorption of the yolk-sack. From the 10th of May till the 1st of July they were fed regularly, and but few died. The whole lot was in July placed in Williams and West Rivers.* The number set at liberty is put down at 30,000.

6.—OPERATIONS IN 1870.

The spring of 1870 witnessed the first introduction of salmon from Lake Ontario. The establishment of Mr. Samuel Wilmot, at Newcastle, Ontario, started originally in 1866 as a private experiment, had attained such importance as to attract the attention of the Canadian government, and induce the department of marine and fisheries to assume the responsibility of carrying it on, for the general purpose of improving the fisheries of the Dominion.

The difficulties in the way of getting spawn from the maritime provinces induced the commissioner of fisheries of the State of Maine to apply to the superintendent of the Newcastle establishment for a small number of salmon-eggs. The application was referred to the department and was granted; and henceforth the sale of eggs became one of the objects of the establishment. The price of salmon-eggs was fixed at $40, in gold, per thousand. As compared with all previous rates, this was high. The price paid Mr. Stone by the States of New Hampshire

* Letter of Prof. A. D. Hager.

and Massachusetts in 1868 was $16 per thousand, and none of the parties offering New Brunswick eggs for sale had asked more than $20 per thousand.

Eight thousand were purchased by Maine, and as the ratio of unfertilized eggs appeared to be about 2½ per cent., 8,200 eggs were packed up. After a journey of three days they arrived at Alna, Me., and were unpacked April 3. The number dead was 870. By immersing them in a solution of common salt the opacity which is the regular attendant on death disappeared, and it was easy to distinguish the fecund eggs from the infecund; the latter counted 640, the former 230; which shows that the ratio of infecund eggs was about 8 per cent. The deficiency was made up, and, of the 8,000 good eggs, 7,400 were hatched. These were kept in an artificial pond one year, being reduced in number meanwhile, from unknown causes, to 1,500. These were set at liberty in May, 1871, in the Sheepscot River.

The introduction of these Ontario salmon is mentioned in connection with those from New Brunswick because the purpose of their introduction was the same, namely, the restocking of the rivers where they were placed with sea-going salmon. To the first purchasers of these eggs it did not occur that there was any doubt about the Ontario salmon taking readily to sea-water and the food to be found there; although it was the expressed opinion of Mr. Wilmot that, while the Ontario salmon were true *Salmo salar*, they nevertheless, in general, passed their whole lives in the fresh waters of the lake, finding there a congenial food. It appears probable that Mr. Wilmot is right in both particulars, but at the present time it must be regarded as an undecided point whether the Ontario salmon do migrate to and from the sea; and, if their residence in the lake becomes established, it will still be an open question whether they can, on being placed in our rivers, assume the migratory habits of the salmon of the coast.

A small lot of eggs from the Newcastle establishment found its way by another channel into the hands of W. S. Peavey, esq., of Whiting, Me. He had them hatched out, and the young fish, numbering 225, were placed in the Cobscook River in May, 1870.

Mr. Goodfellow again undertook the collection of salmon-spawn on the Miramichi in the fall of 1870. A considerable quantity was engaged, but only 8,000 eggs obtained. These were divided between the States of Maine and Connecticut, and the Poquonnoc Fish Company. The share of Maine amounted to only 800. They were hatched out near Augusta, and soon after the absorption of the sack disappeared; it is supposed that they escaped into a tributary of the Kennebec. Connecticut received 2,000 eggs, and had them hatched at Poquonnoc. They produced 1,876 young, and these, without accident or loss in transportation, were, in April, 1871, placed in the waters and tributaries of Broad Brook, a branch of the Quinnebaug River.*

* Fifth Report of the Commissioners of Fisheries of the State of Connecticut, 1871, p. 20.

7.—OPERATIONS IN 1871-'72.

In March, 1871, the Connecticut commissioners bought 10,000 eggs of Ontario salmon at Newcastle. They reached the hatching-house of the Poquonnoc Company March 11, and on opening them 7,000 were found to be spoiled through defective packing. Another lot was immediately sent to make up the deficiency, and from both shipments 6,000 fish were hatched, and placed in the Housatonic, Farmington, Shetucket, and Quinnebaug Rivers.

The first attempt to stock with salmon any of the rivers south of the Connecticut was made in 1871, by Mr. Thaddeus Norris and some other gentlemen, who purchased 11,000 eggs at Mr. Wilmot's establishment, and hatched them out for the Delaware. An accident reduced the number of fry to 2,000, and these were placed in the Bushkill, a tributary of the Delaware. In 1872 the same gentlemen got 12,000 eggs from Mr. Wilmot, and hatched 11,000 of them at a spring within a mile of the Bushkill.

The State of Rhode Island made its first attempt at the restoration of salmon in 1872, by the introduction of 9,000 eggs from Mr. Wilmot's establishment. They were placed in the hatching-troughs at Ponegansett February 11, and hatched in March. The young were placed in the Pawtuxet River.

B—SALMON-BREEDING ON THE PENOBSCOT.

1.—PRELIMINARY CONSIDERATIONS.

Though it was well known that the salmon-fishery of the Penobscot was better preserved than that of any other river on the Atlantic slope of the United States, and the project of obtaining thence a supply of eggs for the stocking of other rivers had occurred to me earlier, it was not until 1870 that the project received serious consideration. The earlier attempts at the collection of salmon-spawn for New England rivers had very naturally been made in the rivers of New Brunswick, where the abundance of salmon and the ease with which they were caught on their spawning-grounds seemed to promise sure and speedy success. Various causes, already sufficiently set forth in the detailed accounts given above of the several expeditions to the Miramichi, rendered the operations there less successful than had been anticipated. The purchase of salmon-eggs at the establishment of the Canadian government in Ontario required an expenditure greater than appeared to be warranted by the circumstances in which the fishery-commissioners found themselves placed, and, besides, there was some doubt whether the Ontario salmon would readily adapt themselves to our rivers and the sea into which they empty. The necessity of having a more abundant supply of eggs, at the cost of collection, was forcing itself upon the minds of the commissioners of all the States interested in the collection of salmon.

In 1870, being then commissioner of fisheries for the State of Maine, I determined to make an effort to find a supply of eggs in the Penobscot, and in October and November of that year I made two expeditions to those portions of the river where it appeared most probable that the breeding-grounds of salmon lay, exploring with canoe the river from Mattawamkeag up to Ambejegis Falls, on the west branch, and to the Seboois stream on the east branch, or Mattagamon. The result of these explorations was the discovery of many localities where salmon might be expected to spawn at the proper season; of others, visited at the right date for such a discovery, where their newly-made nests were actually found, and of some where facilities existed for the collection of spawn. That part of the Mattagamon near the Wassaticook and Seboois streams appeared best fitted for the natural breeding of the fish and for the collection of their spawn, and although the number of nests made before November 3 (some twenty-five or thirty being seen in a distance of three miles on the river) was not large, it appeared to warrant the expectation that a considerable number of eggs might be collected here at a moderate expense. But as the number of salmon to be caught in the vicinity at any season is very small in comparison with the number caught in the tidal parts of the river, it occurred to me that if salmon caught in these rivers could be kept alive and in good condition from June and July, when they pass up the river, till October or November, when they lay their eggs, operations might be carried on there on a much larger scale than here. Being in correspondence, about this time, with Rev. William Clift, of Connecticut, in relation to the breeding of salmon in some of our rivers, he also suggested the latter plan of operation as the one most likely to give satisfactory results. The co-operation of the commissioners of fisheries of Connecticut and Massachusetts was secured, and it was determined to try the experiment of collecting spawn near the mouth of the river.

2.—OPERATIONS IN 1871.

The place finally selected as the site of operations was Craig's Pond Brook, in the town of Orland. This stream has its rise in Craig's Pond, a small body of water of exceptional depth and transparency, tenanted by trout, smelts, and sticklebacks, and probably some other species of small fish, but entirely wanting in the pickerel, perch, sun-fish, and cyprinoids that inhabit nearly all of the ponds in the southern part of Maine. The stream runs alternately over coarse sand and ledge for half a mile, and empties into Allamoosook Pond, making in this short course a descent of probably 200 feet. A few rods above its mouth it receives the waters of several large springs of very pure water, having a temperature of 47° F. At this point there had formerly been a dam to supply power to a shingle-mill. This dam was rebuilt, and a pond formed about forty rods in area and 7 feet deep. So

clear was the water that objects could be seen on the bottom at the deepest point. In this pond it was proposed to keep the adult salmon.

A smaller pond was made at the very mouth of the brook for temporary uses. To this point the salmon could be brought direct by water from the weirs that are built about the mouth of the Penobscot. The nearest salmon-weirs were those near the lower end of Wetmore Island, (town of Verona,) and the salmon from these would have to be towed through five miles of salt and brackish water to Orland Village, then up Eastern River and across Allamoosook Pond, four miles more, to Craig's Pond Brook, passing, on the way up the river, three locks.

The salmon were obtained from several weirs in Verona. They were placed in a boat prepared for the purpose by piercing its bottom and sides with auger-holes to provide a free circulation of water, ballasted and buoyed to keep it at its proper level, covered with a net to prevent the fish jumping out, and towed after another boat propelled by oars. On the 7th day of June the first lot of salmon was brought to the works.

Twelve were placed in the boat at starting, but eight died on the way, and the remaining four were nearly dead. As there were only a dozen inch-holes in the bottom, it was thought that the poor success of the first experiment was owing to the lack of pure water. Another trial was made, with better provision for change of water. Seven salmon were put into the boat, and four of them came safely to the pond. But it was not until a hundred holes were made in the boat that the salmon were brought without serious loss. On neither occasion did there appear to be any difficulty during the passage through the comparatively cool waters of the river below Orland; but on coming into the warm fresh water at the lock at Orland Village the bad effect of the imperfect change of water became apparent. The improvement in the transporting boat enabled us to convey, in some cases, as many as ten fish at a time without losing any.

The work of transporting continued until June 20, when it became apparent that the arrangements for keeping the salmon were altogether unsuitable. After being placed in the pond prepared for them in the brook, the salmon never appeared to feel at home. They swam heedlessly about as if blind, often with parts of the fins out of water. In a few days white blotches appeared upon the surface of the head and back, and at last spread to the sides and lower parts. These blotches were found to be caused by a kind of fungus growing beneath the scales and pushing them from place, and before they had spread to all parts of the body the fish commonly died. Precisely what was the cause of the disease I cannot even yet say; but it must be sought among the peculiar conditions under which the fish were placed. The temperature of the pond ranged from 50° to 56°, while that of the rivers and streams that salmon naturally frequent is, at that season, probably from 65° to 70°. The extraordinary transparency of the water may have had some effect. Some of these fish, very badly afflicted, recovered when placed

in a pond where they had access to deep water. Finally the bottom of the pond was covered with vegetation that had become established there during several years when the dam was out of use, and in its decay it probably imparted some deleterious substances to the water. But, from whatever cause, the mortality was such as to threaten the speedy termination of the experiment by the total loss of the fish.

It was decided to abandon the brook and construct a pound of brush and netting in Allamoosook Pond, in which to keep the salmon that should survive. This pound was built at the mouth of Craig's Pond Brook, and inclosed an area of about twenty-five square rods, extending from the shore to a point where the water was 7½ feet deep. At this depth nothing could be seen from the surface, the water being of a brown color, like nearly all the pond and river water in Maine. The pound was completed on the 27th, and the nineteen salmon remaining on hand were placed therein. Such was their condition, however, as the result of their stay in the brook, that probably few, if any, lived through the summer.

Of the salmon received after this date, twenty-five in number, eighteen survived until the close of the season in good health. The last salmon were brought July 11, and after the 13th there was but one death.

During the summer the level of the pond fell, till the depth of water in the salmon pound was less than four feet. The average temperature of the surface was 64°.7 F. at the close of June, 73° during July and August, and as high as 62°.9 in September. The bottom temperature was not observed, but as the depth of the water constantly decreased until some time in September, when it was only 4 feet, it is probable that the temperature at the bottom was much higher in August than in July. In view of this probability, the fact of fewer salmon dying in August (only one) leads to the conclusion that the losses experienced in this pound were not the result of the heat, but of the injuries received in capture and transportation. In short, all the conditions attending their confinement appear to have been well suited to their wants. The narrow space which the receding water left them to swim in, being at the lowest ebb only 30 or 40 feet square, appeared to cause them some uneasiness, but the walls of the pound were secure and none escaped.

While the pound was building nine of the least healthy salmon in the brook were removed to Craig's Pond and turned loose. It is supposed most of them lived through the summer, for a careful watch for dead and floating salmon was kept up without discovering any. On several occasions salmon were seen swimming near the shore of the pound or leaping into the air. It is probable that the fish retired to deep water immediately on finding themselves at liberty, and that the protection there afforded against the glare of light, the character of the water, and other circumstances were favorable to a recovery from the malady that had attacked them and would have killed them if they had not been

removed from the brook. At the spawning season preparations were made to catch them in the brook should they chose to enter it in their search for a spawning-bed. About the 9th of November it was discovered that on a gravelly bottom under two feet of water, close by the shore, and within a dozen rods of the outlet of the pond, salmon had been spawning. A net was set here on the 10th, and on the morning of the 11th it caught two male salmon. Another was taken on the 12th, but, though the net was kept in place until the 23d, it took no more males and not a single female. The males taken were thinner than those from our pound in Allamoosook, had less red and more blue in their color, and bore large scars on their sides; otherwise they appeared to be in good health. This experiment at Craig's Pond showed that salmon cannot be relied upon to enter a small brook in search of a spawning ground when the water of the pond in which they are confined is pure and the bottom is gravelly and clean. In such cases they will lay their eggs in still water.

A third brood of salmon, eighteen in number, were placed in Dead Brook, a tributary of Eastern River, entering it several miles lower than Craig's Pond Brook, and accessible from the salmon weirs by passing through only one lock instead of three, as in the former case. Dead Brook is larger than Craig's Pond Brook—barely large enough to drive a saw-mill under a moderate head in spring and fall. In midsummer its head is very small, but it never completely dries up. Its water is less pure and more highly colored than that of Craig's Pond, but not darker than that of common brooks. Where the brook traverses a meadow two barriers were placed across it, making an inclosure about 200 feet long and 30 feet wide, with water 5 feet deep at the time the salmon were put in, (June 26 and 28,) but falling to less than 3 feet in September. Two of the fish died in June, but, so far as could be known, the remaining sixteen lived in good health until October. There were occasional freshets that brought down a great deal of mud, but this did no harm. On the 12th of October an extraordinary freshet carried away the barriers and let the salmon free. The most of them must have remained in the brook, for quite a number of spawning-nests were discovered after the water subsided in November, but only a single pair of salmon were seen; these were a mile further up the brook, above some difficult falls, lying side by side in the deepest part of a pool, while just below them, on a rapid, was a partially formed nest. The female fish was caught, killed, and carried several miles to the hatching-house, where her eggs were taken and milted. They were not so well fecundated as the other lots. I am uncertain what was the reason. The fish was afflicted with sores and very weak.

A fourth brood, numbering eleven salmon, were placed in Spofford's Pond, in Bucksport. These were caught in a weir near Bucksport village, and hauled in a tank of water on a dray one mile to the pond. There was no great expectation of catching many of them, but it was

desirable to test the effect of confinement in a pond of this character. It is a piece of water about sixty acres in area; is very deeply colored by the exudations of extensive meadows that drain into it, and its bottom, except a narrow belt along part of the shores, is composed of soft, peaty mud. The brook by which it discharges into the Penobscot is of sufficient volume to drive a grist-mill during the greater part of the year. Three of these fish were found in this brook at the breeding season, and, as several nests were seen, it was supposed that others had descended from the pond unobserved. But a single one was caught. This one was a male, in excellent condition, and in color much richer than any caught elsewhere. Thus the various mishaps of the season left us for a breeding stock only the eighteen fish in the pound at Craig's Pond Brook.

As the breeding season approached, preparations for the development of the eggs were made by fitting up a room in the basement of an old mill at the mouth of Craig's Pond Brook. Water taken from the open brook, which, though of small volume, is impetuous in character, dashing down over a ledgy bed, was led through several wooden troughs, each 18 feet long, 15 inches wide, and 8 inches deep. Grilles, made by setting narrow strips of window-glass on edge in wooden frames, were placed in these troughs, about an inch from the bottom. The eggs, when deposited on the grilles, arranged themselves in rows across the trough, each row lying on the edge of a glass rod, and between two other rods. The space underneath the grilles allowed the constant passage of a current of water, preventing stagnation, and a like current passed over the grilles. No attempt was made to filter the water, it being already uncommonly clean for brook water.

On the 2d of November the breeding fish were for the first time seined out from the pound and examined. There was no indication that any of them had begun to spawn, although if kept there many days longer it is not unlikely that they would have deposited a part of their eggs on the clean, sandy bottom. All of the males were found ripe; several of the females partially so, and 12,500 eggs were taken and fecundated. The fish were all returned to the pound to be seined out again another day. The work was continued daily until November 10, when all the ripe fish on hand had been deprived of their eggs, with a single exception. From one of the females we failed to obtain any eggs, and at last came to the conclusion that she was quite barren. She was, however, kept in the brook, and occasionally examined, until December 12, when she gave a few eggs that were apparently good, but could not be tested for want of milt. Dissection then showed that her ovaries contained a small number, probably a thousand, eggs, of nearly or quite full size and healthy appearance, and a much larger number that were not half grown. With this exception all the females yielded full litters of eggs, that came with ordinary ease, and were, as the result of incubation showed, in a state of complete development

and perfect health. The males yielded an abundance of healthy milt. After being stripped the salmon were placed in the small pond in the brook, near its mouth. While here the exhibitions of the sexual instinct were very marked. Lying in a current, the females would go through all the manœuvers of depositing the eggs, though they had already been deprived of all that we could press out. I have repeatedly observed the presence of eggs in the ovaries of fish of the salmon family months after the lapse of the ordinary spawning season. I should attribute the action of these spawned females to a reproductive impulse of a more general nature. The males were at this time very attentive to the other sex, and Mr. Dresser, our foreman, distinctly witnessed the emission of a cloud of milt by one of them while near a female.

The mode of fecundation employed was an imitation of what is known as the Russian, or dry method, the distinctive feature of which is the exclusion of water from the eggs until the moment of the application of the milt. Vrasski, the originator of this method,* was accustomed to

* The experiments and observations of Vladimir Pavlovitche Vrasski were made at an establishment founded by him in 1860, in the government of Novgorod, district of Demiansk. In 1856 his observations led him to conclusions thus detailed in the bulletin of the Societé d'acclimation, Paris, August, 1871:

1°. Étant reçus dans de l'eau au moment où ils sortent du poisson les œufs la resorbent, et ne gardent le faculté d'être fécondé, que tant que cette résorption n'est pas finie, c'est-à-dire pendent une demi-heure au plus. Une fois remplis d'eau, les œufs ne recoivent plus les spermatozoides.

2°. Les spermatozoides de la laitance, en tombant dans l'eau, commencent immediatement à faire avec beaucoup de vígueur et de rapidité, des mouvements qui ne cependent qu'une minute et demi ou deux au plus; ce laps 'ecoulé, on ne voit plus que dans quelques rares spermatozoides des mouvements particuliers et convulsifs de l'agonie. Quand, au sortir du mâle, on reçoit la laitance dans un vase sec, elle ne change pas pendent plusieurs heures, et dans cet intervalle les spermatozoides ne perdent pas la faculté de se mettre à bouger des qu'ils se trouve en contact avec de l'eau. Enfermé dans un tube sec, et bien bouché, la laitance conserva sa vertue fécondante pendant six jours. Considérant ces observations ainsi bien que les œufs et la laitance sont obtenus avec lenteur, leur masse entière ne pouvant sortir à la fois, M. Vrasski arriva à la conclusion qu'en les recivant dans de l'eau, la plus grande partie dés œufs se reussissent à se saturer d'eau, et que les spermatozoides cessent presque tous de bouger avant qu'il soit possible au pisciculteur de mélanger les œufs avec la laitance délayée. M. Vrasski adopta donc le système des vases secs, et versa sur les œufs la laitance ausitôt qu'il venait de l'étendre d'eau. Le succes fût complet; les œufs se fécondèrent tous sans en excepter un seul.

[Translation.]

1st. If the eggs are received in water as soon as they come from the fish, they absorb it, and preserve the capacity of fecundation only while this absorption is unfinished—that is to say, for half an hour at the longest. Once filled with water, the eggs no longer take in the spermatozoids.

2d. The spermatozoids of the milt, on falling into the water, immediately begin a series of rapid and vigorous movements that continue only for a minute and a half, or two at most; after that, nothing is to be seen except, in here and there a spermatozoid, disconnected, spasmodic movements. When the milt is taken from the male directly into a dry dish it does not change for several hours, and during this time the sperma-

take the eggs and milt in two separate dry dishes, then put water with the milt and turn the mixture immediately upon the eggs. I carried the dry feature a step further, taking the eggs and the milt into a dry pan and securing contact of the milt with every egg before allowing water to touch either of them. The contact was secured by moving the pan rapidly in a circle so as to send the eggs whirling together over its bottom. This being effected, water was added, and after standing fifteen or twenty minutes, or until the eggs ceased to adhere to the pan, they were carried to the hatching-house and placed upon the grilles. When sufficient time had elapsed, and the fecund eggs began to develop, it was found that they were 96 per cent. of the whole—a very gratifying result. The following table exhibits the number of eggs taken, the ratio of fecundation in each lot, and the number lost by the white diseases:

Lot.	When taken.	Estimated number of eggs.	Percentage fecundated.	Number of white eggs.	Number of eggs pack'd Dec. 18.
1	November 2	12,500	100	93	12,500
2	November 3	11,500	94	187	20,650
4, part 1	November 6	9,500	92½	297	
4, part 2	November 6	*3,000	85	510	....
3, part 1	November 4	300	(†)	4	....
3, part 2	November 4	2,500	95	17	1,700
3, part 3	November 4	16,000	96	131	21,400
5	November 7	5,000	100	144	
6	November 8	4,500	100	10	
7	November 9	7,000	97½	134	14,250
8	November 10	85	100	....	
9	November 10	50	100	2	
10	November 10	365	100	2	
		72,300	96	1,531	70,500

The temperature of the water was, at the beginning of incubation, 46° F., but from November 23 to December 18 the average was about 41°. The eggs came forward sufficiently to be transported on the 18th

tozoids retain the faculty of setting themselves in motion whenever they find themselves in contact with water. Inclosed in a dry tube, and well corked, the milt preserves its fertilizing properties for six days.

Taking into consideration these observations, and the fact that both eggs and milt are slowly obtained, their entire mass not coming at once, Vrasski reached the conclusion that, when in water, the greater part of the eggs filled themselves with water, and the spermatozoids ceased to move before it was possible for the pisciculturist to mingle the eggs with the diluted milt; he therefore adopted the system of dry dishes, and turned the milt upon the eggs as soon as he had diluted it. His success was complete; the eggs were fecundated without a single exception.

* These eggs came from the single fish caught in Dead Brook. The fish was killed when caught, carried about three miles, and, after it had been dead perhaps two hours, the eggs were taken and fecundated. On packing up they were found to be so defective that they were turned out into the brook.

† These were purposely left unfecundated.

of December, the circulation being at that time established in all the fecund eggs. They were packed for transportation in tin boxes in layers between wet moss. Each layer of eggs was placed between disks of mosquito-netting stretched on rings of brass wire to facilitate the work of packing and unpacking. The cans were inclosed in sawdust in the usual way. The eggs were divided as follows:

To Maine	21,750
To Massachusetts	21,750
To Connecticut	21,750
To William Clift	5,250
Total shipped	70,500

The portion belonging to the State of Maine was placed for hatching in the care of Crocket & Holmes, of Norway. They hatched out with a trifling loss, and in the spring were turned into a small brook tributary to the Little Androscoggin River, which enters the main Androscoggin just below Lewiston Falls. As the brook had been cleared of its trout to supply the breeding-works of Messrs. Crockett & Holmes, it is probable that an unusually large proportion of the young salmon survived the dangers that ordinarily attend them when turned out into open waters. The eggs belonging to Massachusetts were hatched at the State hatching-house in Winchester, and turned out remarkably well, as exhibited by the following statement:

Whole number sent		21,750
Died during transportation	289	
Died during incubation	141	
		430
Number hatched		21,320

Very few of these were lost, at least 21,000 good, healthy fish remaining on hand when ready to turn out into the stream. The number of deformed fish was small. Of the healthy fish 5,000 were put into a small river on Cape Cod, and the remainder into the Pemigewassett River, a tributary of the Merrimac.*

Of the eggs belonging to Connecticut, 4,579 were lost in transportation, hatching, and nurturing. The remainder, about 17,000, were distributed in various rivers, mostly tributaries of the Quinnebaug. †

Of the 5,000 belonging to Mr. Clift, nearly all were hatched, and in May were turned into Great Brook, the first large mill-stream tributary to Long Island Sound east of the Thames River. ‡

* Letter of E. A. Brackett.

† Sixth Report of the Commissioners of Fisheries of the State of Connecticut, 1872, pp. 26, 27, 28.

‡ Letter of Rev. W. Clift.

Notwithstanding the great mortality among the parent fish, which seriously reduced the stock of eggs obtained, the experiment must be considered successful. There was no longer any doubt that salmon could be kept in confinement in a small inclosure, in fresh water, from June until November, without any injury to their health, or any interference with the development of their eggs and milt, and the conditions of success were now sufficiently plain. Spring brooks, newly-built ponds, and very clear lakes must be avoided, and dependence placed on ordinary pond or brook water with a muddy bottom.

The cost of collecting and developing these eggs, up to the shipping-point, was at the rate of $18.09 per thousand, and it was evident that, with the benefit of the first season's experience to guide in the care of the parent fish, this would become the most economical mode of collecting salmon-eggs available to the New England States.

3.—OPERATIONS IN 1872.

The parties interested in the experiment in 1871, together with the State of Rhode Island and the United States Commissioner of Fish and Fisheries, united in operations on a larger scale in 1872. The disadvantages connected with the site at Craig's Pond Brook, as detailed above, were such as to render a change very desirable, and a small pond in Bucksport, variously denominated "Great Pond," "Spofford's Pond," and "Salmon Pond," was selected as the new site of operations. This body of water, about sixty acres in area in the summer season, receives the drainage of a small tract in the interior of the town, through very small tributaries, that are completely dry in summers of ordinary dryness. There are a few springs near the shores, but the volume of water they discharge into the pond is very small, and in a very dry season the overflow nearly ceases, sometimes entirely. Around the pond are extensive meadows, that are overflowed the most of the time between October and June, and whose drainage imparts a dark, peaty color to the water, and deposits at the bottom a thick stratum of soft mud. The shores, except adjoining the meadows, are stony, and the adjacent bottom, down to a depth of from 3 to 6 feet below the surface, at summer level, is stony, gravelly, or sandy, for the most part hard, partially overlaid by a dark, peaty sediment. The bottom adjoining the meadow is peaty, and supports an abundant growth of aquatic vegetation, such as *Nuphar*, *Nymphaea*, *Brazenia*, *Potamogeton*, &c. The same vegetation grows to a less extent along nearly all the shores. The fishes inhabiting the pond are perch, (*Perca*;) sun-fish, (*Pomotis*;) pickerel, (*Esox*;) hornpout, (*Pimelodus*;) trout, (*Salmo fontinalis*,) very rare; eels, (*Anguilla*;) suckers, (*Catostomus*;) and a few other species of cyprinoids. The water is, in general, about 9 feet deep in mid-summer, and 13 or 14 in the fall and spring, when the pond is full. The outlet of the pond is commanded by a dam and gate, which regulate the flow of water for the use of the mills at the mouth of the brook. The brook is nearly a mile in length, for the greater part of its

course descending gently, but, as it approaches the Penobscot, rushing down over ledges at a grade that probably prevented any kind of migratory fish ascending, even before the erection of dams. Were it not for the natural impediments, the stream and pond would doubtless have been frequented by alewives. The volume of water is sufficient to drive a saw-mill nearly half of the year.

The plan of operations was essentially the same as the preceding year; the parent salmon were to be obtained alive in May, June, and July, and confined in fresh water until the spawning season. The place selected for confining them was the lower end of the pond, where an enclosure of some four acres was made by building a barrier of stakes and brush across from shore to shore, a distance of about 400 feet. Salmon placed herein would have access to the brook that forms the outlet of the pond, and would be kept by the barrier in such close proximity that when the breeding season arrived they would readily find the running water, and, passing down through the gate, would be in a narrow brook, where we could catch and manipulate them.

The salmon could be obtained only from the weirs, which are, in the vicinity of Bucksport, the only means employed in catching them. Arrangements were made with a number of fishermen to take salmon alive from the weirs and deliver them in good condition at Bucksport. They were provided with canvas bags with which to dip the salmon from the weirs to avoid the mutilation they receive from dip-nets, and with perforated boats in which to convey them to the place of delivery. These boats were the common "dories" in use by fishermen on the New England coast, and by cod fishermen on the banks. They were furnished with a smooth lining of boards inside, were perforated with large holes fore and aft, which could be closed when it was desirable to keep out the water, as when towing them empty back to the weirs, and covered with a strong net to prevent the fish from jumping out. When the boat was depressed with the holes open it was half filled with water, and when it was in motion a current ran freely through it, while iron gratings confined the salmon within a space 7 feet long in the middle of the boat, and prevented their escape through the holes. The weirs in use on the Penobscot, elsewhere described in detail, are so constructed that the salmon, together with other fish caught in them, are left by the receding tide on a board floor, where they soon die. In taking them for breeding purposes, the fisherman visits his weir a short time before low water, while there is still water enough above the boards for the fish to swim in. The salmon boat is brought alongside, and into it the salmon are carefully dipped. The same boat takes the salmon from several weirs, and as soon as they are all collected, or as soon thereafter as the flood-tide makes, the laden boat is taken in tow by a dory, which is propelled by wind when that is favorable, otherwise by oars, and brought to Bucksport. At first the salmon taken on the night tides were brought and

delivered immediately, but it was soon found that a considerable number of them could be kept in a boat over night when anchored in a current, and after that transportation by night was seldom attempted. The distance from the Bucksport landing to the nearest weir that furnished breeding salmon was less than half a mile, and to the farthest less than five miles. They were all in the towns of Verona and Stockton.

The collection of salmon might have begun as early as May 1, but the price was at that date high and only small numbers were caught. By the 1st day of June they were more plenty and the price had fallen to 30 cents per pound. The first salmon was received June 1, but they came in slowly during the first eight days, only twenty-five being received during that time. On the 10th, however, came twenty-three salmon, and on the 11th forty-eight, the largest number received on any one day of the season.

On the arrival of a salmon-boat, a dray carrying a large wooden box was backed down into the water, so that the boat could be drawn up to it, and the salmon dipped over into the box, which was partly filled with water. The box was three feet long, two wide, and two deep, containing, therefore, nearly ninety gallons of water when full. It was provided with a sliding cover, and a single hole in the center of this was found to admit an ample supply of air. A salmon of average size could lie at length in it easily, but one of the largest size could do so only when in a diagonal position. Six or eight salmon were commonly put into a box together, and this number sustained but little injury during the overland journey of one mile. As soon as a box had received its complement of fish it was filled brimful of water and drawn to the pond, where it arrived in about twenty minutes. The dray was backed into the pond until the box floated, or nearly so, and the salmon turned out gently. Some of them swam off at once into deep water, but often they were very sluggish, and lay for a long time in the edge of the water. A few died immediately, and others after a day or two. When the river-water with which the boxes were filled was cool and clear the salmon suffered much less than when it was warm and roily.

A part of the mortality was doubtless due to injuries received by the fish in dipping them from the weirs, or in transferring them to the boxes. Some were injured by rushing violently against the gratings in the boat, or against the sides of the boxes. This happened frequently during the last ten days of the collecting season, for the salmon had then become more restive than at first. The increased restlessness and activity of salmon at that time is recognized by fishermen, who call these salmon "jumpers," with reference to the habit of jumping into the air, which is observed oftenest at that date, (about the 1st of July,) and which is regarded as the characteristic of a particular school of salmon. This phenomenon, which appears to be pretty well established, might be supposed to be caused by the influence of an increase in the temperature of the water, but the observations made at Buckport, in the Penobscot

from June 17 to July 15, 1872, do not show any marked increase in temperature during that time.*

The number of salmon bought in June, from the 1st to the 15th, was 231, and the average weight 12.2 pounds; from June 16, to 30, 309 salmon, averaging 12.5 pounds; from the 1st to the 8th of July, 152 salmon, averaging 12.2 pounds; which shows a remarkable uniformity in weight at different dates. Of the whole number bought, 692, there were only three that weighed less than eight pounds; one of these weighed seven, another six, and another two pounds. The largest weighed twenty-eight pounds.†

It was impracticable to distinguish between the sexes, and I bought indiscriminately. Toward the close of the season, however, distinctive marks were quite perceptible.‡

The dark color of the water and of the bottom in the salmon pond tended to a high summer temperature. From June 20 to the close of August four observations daily were made on the temperature of the water, both at the bottom and at the surface, and of the air; the hours being sunrise, 7 a. m., 1 p. m., and 9 p. m. The bottom temperature was observed at the depth of 10 feet in June, and 8 feet in August, by means of a milk-can sunk to the bottom and kept there all the time except when making the observation; it was then drawn up by a line that was constantly attached to it; the cover was removed, and the bulb of the theomometer being plunged into the water the mercury quickly settled at the proper point. I think this a very safe and accurate mode of observation, as it is certainly a very simple one. The mean temperature at the bottom on June 20 was 60° F. and at surface 71°.6, the mean temperature of the air being 64°. The highest bottom temperature observed was 62°, and the lowest 60°. The mean for the last eleven days of June was, air, 64°.38; bottom, 60°.53; surface, 72°.62; the water at the surface being thus about eight degrees warmer, and at the bottom about four degrees colder, than the air. In

* The mean of six observations of surface temperature in the channel between Bucksport and Verona on June 17 and 18 is 61°.8 F.; at bottom at same place in 30 feet of water the mean of five observations on same days is 46°.4 F. On 7th, 8th, and 9th July six observations at same point give a mean of 66°.3 F. at the surface, and 50°.3 F. at the bottom. Observations made at the south end of Verona fail to show any higher temperature between July 10 and 15 than between June 19 and 23. Observations in the main channel of the Penobscot opposite Bucksport might give a different result, but not, it is believed, to a great degree. (See table 4.)

† The weight was arrived at by estimate, at sight, no practicable mode of weighing the fish presenting itself. Persons accustomed to handling and weighing salmon soon learn to judge their weight by the eye so accurately that an error of a pound in the weight of a fish of average size will seldom occur. But there is, of course, a greater liability of error than there would be with the use of instruments, and this fact must be borne in mind in considering the statements of weight of salmon bought. (See table 8.)

‡ As the proportion of the sexes was, however, quite satisfactory, as was found in the fall, the females caught from our pond outnumbering the males nearly two to one.

July the mean temperature of the water at the bottom was only a fraction of a degree lower than the air, the figures being, air, 66°.37; bottom, 65°.39; surface, 72°.45. In August the bottom temperature is higher than that of the air, the means being, air, 67°.01; bottom, 69°.48; surface, 73°.04. Owing to a misunderstanding the observations were omitted during the first half of September, and after that they were only made once a day on the water. The mean was now only 59° at the bottom, 62°.92 at the surface. The last of October the daily observation showed 45°.

On some days in August the bottom temperature was at midday as high as 74°. Yet the salmon did not appear to suffer in the least. During the hottest weather a dead one was rarely found, and their condition in the fall was unexpectedly fine.

Observations made on the temperature of several small rivers in the State in August and the early part of September exhibit averages quite as high as those in the pond,* and I think it altogether probable that in the pools where, in a state of nature, they lie during the summer, they are, in this State, often subjected to a temperature of above 70° F., and always without injury.

Of the salmon turned into the pond, none were found dead until the 12th of June. On the 15th fifteen salmon were found dead in a net that had been hung on the inside of the brush hedge to make it doubly secure. It was a common menhaden net, hung on loosely with the expectation that the salmon would see and avoid it. But the fish exhibited remarkable dimness of vision, and probably became entangled in the net before seeing it. It was therefore removed, and, the brush not proving an efficient barrier, the salmon passed out into the main pond in large numbers. The hedge being then useless, it was taken up. The deaths among the salmon continued, and during June counted, from all causes, fifty-six. Thirty-three died during July, all before the 23d day. In August there were only three deaths, and in September none. As the water was warmest in August, and lowest in September, I think the mortality among the salmon was not owing either to excessive heat or stagnation in the water, nor yet to any incapacity of the water to sustain the life of fish so lately from the sea, but wholly to the mechanical injuries received.

A good many of the salmon, after being placed in the pond, exhibited strong symptoms of uneasiness, swimming slowly to and fro along the shores, as if searching for a way of escape. Occasionally they swam about in compact schools, of perhaps ten to thirty each, near the surface, often with the tail or dorsal fin projecting. Others were continually leaping into the air, now to the height of a foot only, and again six feet high, or higher. While the hedge was standing a salmon was seen to jump clear over it at a point where it was five feet and a half above the water. This salmon jumped out of the enclosure, and it might be thought that the leap

* See tables 3, 4, 5, and 6.

was with the intention of escaping, but another salmon was shortly after seen to jump into the enclosure over the same hedge; and I presume both leaps were made at random.

At times during the summer the salmon would for a day or two almost entirely disappear. This happened on the 1st and 2d days of July, and an examination of a weather record shows that both days were warm, with very light and variable winds, and a clouded sky. But they re-appeared a few days later as active as ever.

This extraordinary activity soon diminished, and by the middle of August had decreased 80 per cent., but there was hardly a day during the whole season, up to the spawning time, when there were not some salmon leaping. Meanwhile they had ceased to frequent the shores, and had become so wary that it was no longer possible to approach within arm's-length of them, as might easily be done during the first days of their confinement.

Late in August, being now confident of the survival of a large part of the salmon, and of a correspondingly large yield of eggs, I began preparations for the spawning season. A site for a hatching-house had been selected on the brook, about 600 feet below the outlet of the pond, and a substantial dam had been built here by Mr. Swazey, the owner of the premises, from whom I had secured a lease. The only source from which to draw a water-supply was the brook itself, there being no spring of considerable size in the vicinity; and the house was accordingly so ocated as to take water conveniently from the dam. The main building was made 70 feet long and 28 feet wide, one story high,* and contained

* It was built entirely of wood, the walls being boarded on both sides of the studding, and the space between filled with sawdust, as a precaution against cold. With the same object in view, the exterior was covered with sheathing-paper and then shingled. Two stoves, one for wood and the other for coal, were provided, with the anticipation that it might prove a difficult task to keep the water in the hatching-troughs from freezing. Happily, the fact proved otherwise. Across the upper or north end of the building ran a feed-trough 11 inches deep and 12 inches wide, which received water from a conduit leading from the dam, and discharged it into fifteen hatching-troughs which ran lengthwise with the building. Thirteen of these troughs were each 60 feet long, 1 foot wide and 6 inches deep inside. The other two troughs were of the same width and depth, and 56 feet long. The trough-room, therefore, measured 892 square feet. A deduction of 18 inches per trough, as an allowance for waste room at each end, leaves 869.5 feet as the total available space for the deposit of eggs. Each trough was fed by a short spout an inch in diameter, and, when in actual operation, was found to use about 300 gallons of water per hour, making 4,500 gallons per hour as the total amount used in the building. The troughs were made of unseasoned spruce boards and put into use without paint or varnish of any kind, or even planing. They were set on the floor nearly level, and had no divisions to check or break the water.

The liability to an excess of sediment from the water of the brook was so great that it was not considered prudent to place the eggs on gravel, and a sufficient number of wire-cloth trays was provided to hold them. The trays were made of iron wire cloth, with wires an eighth of an inch apart, tacked to light wooden frames, two feet long, one foot wide, and seven-eighths of an inch deep; they were varnished with a so-called paraffine varnish to prevent rusting, and were furnished with legs five-eighths of an inch long

trough-room sufficient for the development of several millions of eggs. The building and all the fixtures were in order in season for the reception of the spawn, the first of which was taken October 28.

The preparations for taking spawn were the erection of a rough shed by the side of the brook, some 200 feet below the dam, and the construction of a number of pens in the brook at the same point. The pens had board bottoms and sides, and the ends were of wooden gratings, through which the water passed freely. They were to be used to confine the salmon in while waiting to be manipulated and marked. A gate opened from the upper pen into that portion of the brook lying between it and the dam, and other gates opened from pen to pen, so that the salmon could be driven from one to another. These were all of small dimensions of course, and a dip-net only was required in taking salmon out of them for manipulation. At the dam a small gate was made, nearly as high as the surface of the pond, and the water that came through it ran over a gently sloping floor about 12 feet long, with wide crevices in it, through which the water wasted, while a salmon coming into it would slide down until left without water enough to swim in, when it could not do otherwise than roll off the lower end of the floor into the brook. This arrangement would effectually prevent salmon returning to the pond after once coming into the brook; and being now enclosed above and below, they could be driven into the pens with a small sweep-net whenever wanted. After the first season a long, narrow sluice was built leading from the dam down to the spawning-shed, and in this form the premises are represented in the illustration.

The salmon having now the range of a pond of sixty acres, which would by the flowage of marshes be doubled in November, the task of catching them again for spawning purposes was by no means so easy as it would have been had they remained within the enclosure first made, which contained only about four acres of surface, and which would have kept them from straying more than forty rods from the brook, into which, it was hoped, they would voluntarily run. It was therefore thought necessary to take some new measures for catching them.

First. A hedge, obtusely funnel-formed, was placed across the narrow part of the pond a few rods above the dam, each arm of it resting on the shore, its apex pierced by an opening occupying the center and pointing down toward the dam. Salmon swimming down the pond, on either shore, would find one of the ends of the hedge crossing its path obliquely, would follow it out to the apex, pass through the opening, and then be within an inclosure out of which there would be but two ways of egress—

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to keep them up from the bottom of the trough, so that there might be a current of water underneath, as well as above them. The troughs were not furnished with covers, reliance being placed on curtains at the windows for protection against an excess of light.

After the close of the season the position of the troughs was changed; they were cut into shorter pieces, placed across the building, and fed from a long trough that traversed the room lengthwise. This is the arrangement represented in the plan.

one being the way by which it entered, which it would not be likely to find; the other through the gate into the brook, to which it would have easy access. This structure was completed on the 9th of October, and the large number gathered within it before the close of the month attested its usefulness.

Second. A seine was prepared, 18 feet in depth and about 1,000 feet long, which was of sufficient size to span the pond at its widest part; and this was twice drawn the whole length of the pond toward the dam to drive the salmon inside the hedge. This appears to have done some service, although the character of the bottom, which was soft and studded with an abundance of snags, prevented its being as effective as it would have been on a smooth, hard bottom.

Third. On the two brooks that are tributary to the pond barriers were constructed to prevent the ascent of the salmon, and in the larger one at Redman's Bridge* a pound was made to entrap any that might try to pass that point. These barriers and pounds might have been successful had it not been for a heavy fall of rain, almost beyond precedent, that raised the water quite over their tops and let a large number of salmon pass up the larger brook.

Early in October the salmon showed an increased disposition to rove. There had been sufficient rains to flow the meadows adjoining the pond, and several salmon were observed there about the eighth day in very shoal water. Immediately after the hedge near the dam was completed, the fish began to gather in it, exhibiting great activity, running and leaping. Their manner of leaping, however, was different from that observed in summer. Then the leap was almost vertical in the air; now it was generally more oblique, describing the arc of a large circle. I have seen a salmon in October leap through the air a horizontal distance that I judge to be ten feet, without rising more than three feet from the surface of the water. Such movements suggested that they were either playing or fighting with each other, and that the leaps were accidentally made by salmon that were deluding the pursuit of others.

On the 24th day of October the grating, which up to this time had been kept before the gate, was removed, and a free but small passage was left open for the salmon. One very small male had already got through the grating into the brook, and his milt was found to be mature. Up to the evening of the 26th no more came down. That night it rained so heavily as to raise the pond. The next day, the 27th, a number of salmon were seen to pass through the gate into the brook. It was generally observed that they descended tail first. That was the case in every instance that I observed. The gateway was only eight inches wide, and some of the larger fish, turning partially on their sides as they dropped into it, could hardly get through. It was afterward enlarged.

On the 28th the taking of spawn began. The first eight females ex-

* See map of Spofford's Brook.

amined were found fully ripe. During the day twenty-four in all were examined, and only four of them appeared immature. All the others yielded full litters of eggs, amounting in the aggregate to 273,400 eggs, an average of 9,113 per fish. The small proportion of immature females was unexpected; but it was a welcome fact, since it saved a great deal of labor that would have resulted from the presence of a large proportion of immature fish. The males were all found ripe from the first. They were in smaller numbers than the females, the whole catch during October being fifty-six males and sixty-six females.

The mode of manipulation adopted, as, under all considerations, the best, was the following. The spawn-taker sits on a stool of convenient height, with a shallow ten-quart pan before him. He is so clad that he need not avoid close contact with the wet fish, and when a female salmon is brought him he seizes the tail with his right hand, puts her head under his left arm, and holds the vent over the pan. His left hand is free to press the abdomen and force out the spawn. In this way one man can do the whole work alone, and quite as rapidly as he could with two assistants to hold the fish. The eggs are accompanied by a sufficient quantity of transparent, viscous liquid to insure easy motion in the mass without friction, and to prevent rapid evaporation when they are exposed to the air. The time required to take all the eggs from a single fish varies from five to twenty minutes, depending in a great degree upon the size and disposition of the fish. Sometimes she is exceedingly restive, and in such cases it is found best to suspend pressure while she struggles. The eggs from a single fish form a mass of from three pints to four quarts. As soon as the female fish is relieved of all the eggs she will give, she is handed over to the weighers and markers. The spawn-taker seizes a male salmon, holds him over the pan in the same position as the other, and presses out his milt upon the eggs. The males are stronger, and struggle more than the females, but this part of the operation is soon concluded. When males are present in sufficient numbers, all the milt to be obtained from one is applied to the eggs of a single female; but when, as was oftener the case, the number of the males required economy in their use, each one of them are made to furnish milt for the eggs of two or more females. To distribute the milt thoroughly among the eggs, the pan is now moved rapidly around in a horizontal circle, which sends the eggs and milt whirling about over the bottom, and soon insures contact of the milt with every egg. Water is now turned into the pan, at first in small and then in larger quantites, and the eggs are then set away on shelves ranged around the walls of the shed, where they are allowed to stand until the absorption of water is complete. To facilitate this absorption, the eggs from a single fish are commonly divided among several pans, it being found that while the process may be completed in twenty minutes, with eggs lying in a single layer in clean water, it frequently takes an hour or more when the eggs are heaped on each other.

The presence of a great quantity of milt in the water also obstructs the process, and therefore the eggs are generally rinsed once or twice. As soon as the eggs are completely expanded, and have loosed their hold on the pan, they are poured into a pail and carried down to the hatching-house. In a full salmon the eggs are packed so far forward behind the gills that at the first pressure it is impossible to get them all at once. The fish were, therefore, after spawning, placed in one of the pens and left a day or two, or till a convenient time, when they were taken out and stripped again, this time yielding from two hundred to five hundred eggs each. With this second yield of eggs the success in fecundation was not so good as with the first taken, which I attribute to the presence of an excess of water in the abdomen.

The work proceeded rapidly until the 2d day of November, when nearly a million of eggs had been taken. The fish then came more slowly for a week. On the 7th and 8th of November fell 2.7 inches of rain. The pond rose rapidly, and poured into the brook a flood that overflowed our pens, letting out our salmon, and mingling them with a large number of new-comers. In the hatching-house it rose over the floor and over the troughs, where the eggs were deposited. To keep the floor in place, a few shores had been set against the beams above, but the buoyancy of the floor, or of the air confined under it, broke the shores, allowing parts of the floor to rise several inches, and some of the hatching-troughs swung out of place. In a day or two the water subsided, and was found to have done no harm in the house except that it left a heavy deposit of sediment in the hatching-troughs and on the eggs.

The new rise of the water had brought down a fine lot of salmon, a large part of them ripe and full. Most of those that had escaped from the pens were caught again and kept for marking.

It was at this time that the salmon passed our barriers on the tributary brooks, traversed a mile of meadow beyond them, and gained a rapid, gravelly brook,* when they at once set about the work of spawning. Here they were found on the 10th in a little brook that a child could step across, above rapids where it seemed almost impossible that a salmon could ascend. Quite a number were found dead, and I doubt not that they killed themselves by striking against the rocks in the attempt to climb a difficult fall, which the most of them passed. About seventy fish were caught there, the majority of them females. Many had already spawned, and only about a hundred thousand eggs were obtained from them.

Scattering salmon continued to run into the brook until the 21st of November, when the last eggs were taken. Including those caught at Rich's Brook there were taken about 225 females and 130 males. A more exact statement cannot be made on account of the confusion occasioned by the freshet of November 9.

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*Rich's Brook; see map of Spofford's Brook.

	Salmon.
There were placed in the pond in the summer	688
There had been found dead	92
	596
Caught in October and November	355
Leaving	241

Perhaps as many as 50 salmon came into the brook besides those caught; but that would still leave 191 not accounted for. It was supposed that they would make their appearance at the outlet of the pond in the winter or spring. A few came in February and a few in April, altogether perhaps 25; and there is still a remainder of 166 whose fate is unknown.

The fish caught at Rich's Brook were turned loose without marking. Those at the spawning-shed were all marked, and then set at liberty in the brook, whence they could at pleasure descend to the river. Over the most difficult fall in their way a sluice was built for them to run through, but it was found that instead of entering it they generally dropped over the edge of the dam and fell 16 or 18 feet upon a ledge without any apparent injury. They continued to descend all through the winter and spring.

The mode of marking adopted was by means of metallic tags. Aluminum was the metal chosen, being desirable on account of its lightness and anti-corrosive properties. It was rolled very thin and cut into tags about half an inch long and a quarter of an inch wide. A number was stamped on each tag with a steel die, and a small piece of gold, platinum, or silver wire attached to it. The tag was affixed to the fish in two different ways. The first mode was the attachment of the tag to a rubber band that was slipped on over the tail. The second was running the wire through the edge of the dorsal fin. Forty-two fish were marked in the latter way, one hundred and ninety in the former.

A record is kept of all fish marked, showing the sex, length, and weight of each one, and the date when marked and when set at liberty. The capture and identification of any of these fish hereafter may therefore contribute much toward a solution of the obscure points in the natural history of the species. At the beginning of the fishing season of 1873 I distributed circulars offering a reward of three dollars in addition to the market price for any of these tagged salmon that might be brought to me. But none were received, and I do not think any were caught. About the efficiency of the rubber band I have serious doubts. In many instances that came under my own observation the band had cut quite through the skin, and threatened to destroy the fish. Such, I think, will be the action of any band that is tight enough to stay on. Of the tags attached to the dorsal fin I expect more, and believe that to be the best mode yet suggested.

After the eggs were placed in the hatching-trays it was easy, by counting the number of eggs in a row across the tray, to compute the number in each. A tray of the size most used, two feet long and one foot wide, held about 4,000 of them when they were evenly spread in a single layer. The whole number was about 1,560,000. In taking them the eggs of each fish had, in the majority of cases, been kept by themselves as a distinct lot, the record showing when and how taken, and any noteworthy facts about the parent fish or the manner of treating the eggs.* In a number of cases, for the purpose of trying a series of experiments, the eggs of a single fish were divided into several lots. These were all kept separate in the hatching-troughs, and, although the fortunes of the season frustrated a portion of the experiments, others afforded interesting results.

The evidences of maturity of a spawning salmon commonly observed are, a soft condition of the abdomen and the flow of eggs under pressure. The latter is really less trustworthy than the former, for the fish appears to have the power of constricting the vent so that a man's strength is hardly sufficient to press the eggs out. When a gravid fish is held up by the tail, if the eggs are free from the ovary they run down toward the head, distending the anterior portion of the abdomen and leaving it flabby and loose near the vent. If the eggs are still adherent to the ovary they, of course, retain their position and the abdomen its external shape. The protrusion of the vent, which is one of the marks relied on by some breeders of trout, fails in the case of salmon. In many instances maturity of the eggs is accompanied by the temporary drawing in of the vent quite out of sight, and by its firm constriction. This is nearly always the case while the fish is struggling, whether during manipulation or before, and may, to a certain extent, be an incidental result of the efforts of the fish to get free; but it sometimes continues after muscular action has ceased in every other part.

I think it can be laid down as a general rule that at the time when a female salmon voluntarily begins to spawn, her eggs are all ready to be laid and capable of fecundation. To be sure, my observations have been made on salmon under a certain degree of restraint, which may have interfered to some extent with the normal development of the eggs and the normal exhibition of the reproductive instincts. But in the pond at Bucksport the range was so great that, as far as could be judged from the actions of the fish, they felt after the first few weeks quite at home; and I have seen nothing in their behavior which indicates that the degree of such interference is other than trifling. It is, therefore, presumed that the maturity of the eggs was nearly the same as it would have been in a state of nature.

In the case of the salmon manipulated, nearly every one yielded at once all of her eggs, except such as were packed in the anterior part of

* See table 9.

the abdominal cavity, so far forward that they could not be forced out by ordinary external pressure. The number of the eggs that we failed to get from this cause rarely exceeded five hundred, and averaged not more than three hundred. The rest, constituting 97 per cent. of the whole litter of eggs, came freely, with a uniform appearance of health and maturity, and, in a majority of cases, not one in a hundred failed of fecundation.* There were, however, during the early days of the spawning season, several females manipulated that appeared to be unripe, and such, after a trial which sometimes resulted in the flow of a few eggs and sometimes not, were placed in a pen to be tried again another day. In some of these cases the eggs may have been quite ripe, but voluntarily withheld by the fish; in the most of them, however, the evidence of immaturity was conclusive. From one of these was obtained at first trial three hundred eggs, of which 95 per cent. were fecundated; from another, one thousand eggs, and 22 per cent. fecundated. On being returned to the water these unripe fish made rapid progress in the development of the eggs, and very soon the whole litter was ready to be laid.

It would naturally be supposed that if all the eggs of each fish attain maturity nearly at the same time, the fish will, when left to follow her instincts, be but a short time in depositing them; and the phenomena thus far observed seem to support that view, although from the peculiar circumstances of the case they cannot be regarded as conclusive. The observations on this point were not many. The salmon that came into the brook, at the outlet, while waiting to be driven into the pens, found themselves in water running over a gravelly bottom, had the range of a portion of the brook about ten rods long, the current being moderately strong, and the bottom gravelly. Here they began promptly to lay their eggs, in spite of the crowded condition of the place, and when any of them were left there over night, as was sometimes necessary, both the condition of the females and that of the bed of the brook attested in the morning their industry at egg-laying. A few full females escaped from our pens and lurked in the artificial pond below, coming up in dull weather, and of nights, into the running water just below the pens, and laying their eggs on a fine gravelly bottom; when discovered here they were promptly pursued, so that they were not long left undisturbed; but they managed to make quite large nests, and did it in a very short space of time.

The tributaries of the pond, as has been previously explained, were guarded by hedges and traps, with the design of catching in the latter any salmon that should attempt the ascent of the brooks. With the exception of a single male caught near one of the hedges, about the 1st of November, no salmon tried to ascend the brooks until after the 7th of that month. On the 7th and 8th occurred a heavy fall of rain, so that on the latter day the water flowed quite over the tops of the hedges, let-

* See table 9.

ting a large number of salmon pass up the main brook. On the morning of the 10th I was apprised of their presence in a trout brook, to which they had ascended over rapids that would have been quite inaccessible had it not been for the freshet. Repairing immediately to the spot, with an assistant, I found the bottom of the brook, in every available spot, completely filled with their ridds, and salmon of both sexes, spent or full, occupying all the pools. We caught and examined nineteen female fish, of which six were wholly, and nine partly, spent. If these fish had begun to spawn in this spot, six of them had completed the whole process within forty-eight hours, or sixty at most. There is nothing conclusive about it, since it is by no means impossible that the females found spent on the 10th had begun their spawning before the storm of the 7th at some point on the shore of the pond, and feeling the sudden rise of water, had left the ground where they had already laid a portion of their eggs, and had traveled a mile or two up a small brook in search of a place to deposit the remainder.

The ratio of fecundation was ascertained in from twenty to thirty-five days after the eggs were taken. The germ begins, some days before that, to spread over the surface of the yolk, which it in the end completely envelops. During this process its advancing margin appears to carry along with it a row of colored oil globules, which form a distinct ring on the surface of the yolk. At first it enlarges as it advances, until it has passed half way round the yolk, when it is at its largest size; from that moment it grows smaller, until it finally closes up. In spring-water this phase of development begins at the tenth or twelfth day, and is completed in eight or ten days. During its progress the plainly marked ring of oil globules affords an easy means of distinguishing a fecund from an unfecund egg, since in the latter no such expansion of the germ occurs. A very strong light should be thrown through the eggs to see their condition clearly. This is best accomplished by placing them in a shallow metal box whose bottom is perforated with round holes almost, but not quite, as large as the eggs, placing the latter over the holes, and holding them so that the light shines through them from beneath. The box commonly used at Bucksport contains forty eggs, and if one of them proves infecund, it is held to indicate a rate of fecundation equal to 97½ per cent. If all of the forty are fecund, the rate is 100 per cent. A sample of forty from each lot is thus tested, and as there were in 1872 two hundred and fifty-seven lots, the average result is believed to be very accurate.

The eggs taken from full fish at the time of first handling them, and treated in the ordinary way, were, in the majority of cases, fully fecundated, and the average rate of fecundation obtained by the ordinary way was 98 per cent. There were, however, thirty-eight lots of this sort, in which the test applied gave a proportion of infecundated eggs. In the most of these cases the rate of fecundation indicated was 97½ per cent.; in only three of them did it fall below 90 per cent., being 87½ in two

cases and 67½ in another, the record affording no explanation of either of them. It is probable that few, even of the lots indicated by the trial to be fully fecundated, were quite so, since they had to be judged by samples, a method that does not admit of strict accuracy. In the thirty-eight lots alluded to, the presence of a small percentage of infecundated eggs is certain. The inquiry naturally arises, what was the cause of their failure? It cannot be traced to an insufficient supply of milt; for in two lots that were milted heavier than usual, only 97½ per cent. of the eggs were fecundated, while in another lot, taken on the same day and scantily milted, the percentage was 100.

After being once manipulated, the females were placed in the water to recover from their exhaustion, and await a second manipulation a few days later, when they would yield about three hundred eggs each. The rate of fecundation in these eggs was unequal. On the 1st day of November all the females used before, sixty in number, yielded at a second trial 16,300 eggs, and only 77½ per cent. were fecundated, while in some of the subsequent lots of this kind the fecundation was complete.

The eggs taken from those spent fish that had spawned naturally exhibited the same inequality in their susceptibility to fecundation. I think it is to be explained, not by an original defect in the egg, but by the action of the water that frequently obtains access to the abdominal cavity after it has been emptied of most of the eggs, and when present in great quantities might be expected to exert an influence similar to that which it would exert on the eggs after they had left the fish. It would incite them to expansion, and they would then lose their susceptibility to fecundation. A small quantity of water might remain near the vent or be insufficient to overcome the viscid fluid in which the eggs swim, and which, while it surrounds them, prevents their absorbing water.

From all this it would appear, first, that there are, as a general rule, no defective eggs in the ovaries of a salmon; and, second, that when she first begins to spawn, the eggs are all ripe and ready to be laid and fecundated.

There are exceptions to the first proposition. One of the salmon manipulated at Orland in 1871 yielded no eggs until December, when it was found by dissection that, though her ovaries contained some full-sized eggs, the majority of them were only partially grown, being of a great variety of sizes, from nearly a quarter of an inch down to the fiftieth of an inch in diameter. These were all adherent to the ovary. Unfortunately the lack of milt prevented the testing of the susceptibility of the full-grown eggs to fecundation. There are occasionally found in a lot of healthy eggs a few that are white and opaque on issuing from the fish; and I have found them in the abdominal cavity. I can assign no cause. I have also seen eggs that at the moment of leaving the fish bore to the eye distinct evidence of being in an abnormal state, apparently a stage in the process of disorganization. In some cases, although the egg was of full size, the yolk and the oil-globules only appeared as

a small body of colored matter floating in the transparent fluid that filled the outer shell. This was the case with eggs found in salmon late in the winter and in the spring, and I thought it proceeded from a rupture or shrinking of the yolk membrane of an egg originally healthy. Some eggs of this character were taken with healthy ones from a living fish at the spawning season, and I have found them to abound in fish that had been a short time dead. This, in fact, appears to be the ordinary course of an egg that remains too long in the fish. It is not unlikely that there are imperfections of other kinds than those mentioned, that render the affected eggs incapable of fecundation under the most favorable circumstances. On the other hand, eggs that are in perfect condition on issuing from the fish may fail from a variety of causes. Water may reach them and lie in contact with them too long before the milt is applied; the milt itself may have lost its power through the influence of water or air. Further, it is possible that in some cases the milt is originally inert, or becomes so while yet in the spermaries of the salmon. The latter might easily occur through the influence of water entering by the vent. In manipulating males that have been used once or oftener before, a good deal of water is sometimes pressed out first, but the milt that follows it appears to be efficient. Without continuing these speculations further, I will state the result of several experiments on the fecundation of the eggs.

4.—THE FECUNDATION OF EGGS IN LARGE OR SMALL MASSES, AND WITH OR WITHOUT STIRRING.

Experiment 1.—Lot 25, containing 3,800 eggs, was milted as usual, was then watered and allowed to stand during absorption in one pan without any stirring; (the pans used in all cases were circular in shape, and 11¼ inches in diameter; these eggs, therefore, lay about two deep on the bottom of the pan;) fecundation 40 per cent. Lot 26, containing 7,600 eggs, was stirred five minutes and underwent absorption in three pans; (being 2,533 per pan;) fecundation 100 per cent. Lot 30, containing 7,000 eggs, stirred and set in one pan; fecundation 97½ per cent. Lot 31, 13,000 eggs, milt scanty, stirred two minutes and a half, then watered heavily and set in three pans; fecundation 100 per cent. Lot 33, containg 7,000 eggs, set in one pan; fecundation 100 per cent. The conclusion drawn from these results is that it makes little or no difference whether the eggs are treated in large or small masses, but that it is important that they should be stirred. I suppose that when the eggs lie quietly in a mass just as they were taken from the fish, even though they be covered with water, the viscid fluid that envelops them wards off, not only the water, but also the spermatozoids of the milt, until the latter have become inert. I have observed with certainty that the fluid referred to seriously hinders the absorption of water, and prolongs the process for sometimes an hour beyond the usual time, which is twenty minutes. Stirring assists both the water and milt to penetrate to the egg.

5.—THE SUSCEPTIBILITY OF THE EGGS TO FECUNDATION IN WATER.

Experiment 2, *October* 29.—Lot 34 treated in the usual way; fecundation 100 per cent. Lot 36, from same female, allowed to stand in water two minutes, before the milt was applied, which was done without pouring off the water; fecundation 20 per cent. Water, 44° F.

Experiment 3, *October* 31.—Lot 49 treated with water four minutes before the application of milt; fecundation 7½ per cent. Water, 43° F.

Experiment 4, *November* 4.—Temperature of the water 40° F. Lot 119, treated as usual, was completely fecundated. Lot 120, from the same fish, stood in water several minutes before the milt was applied; fecundation, none.

Experiment 5, *November* 5.—Temperature of the water 40° F. Lots 136, 137, 138, 139 and 140. The milt for these eggs was taken first in a dish, dry; then the eggs were taken, divided and watered; then, after the lapse of one, two, three, and six minutes, respectively, the milt was applied and the eggs stirred; all then stand until free. Results: after one, two, and three minutes, fecundation 100 per cent; after four minutes, 92½ per cent; after six minutes, 65 per cent.

Experiment 6, *November* 11.—Temperature of the water 40° F. Lots 180 to 189, inclusive, were milted successively; the first immediately, and the rest at intervals of from half a minute to ten minutes after they were placed in water. The result was as follows, viz, in the lot milted immediately, 97½ per cent. fecundated; at the end of half a minute after application of water 92½ per cent. fecundated; at the end of one minute 95 per cent.; at the end of two minutes, 77½ per cent.; at the end of three minutes, 80 per cent.; at the end of four minutes, 85 per cent.; at the end of five minutes, 87½ per cent.; at the end of six minutes, 85 per cent.; at the end of eight minutes none fecundated; at the end of ten minutes 2½ per cent. fecundated.

The inequality of these results may be attributed to minor differences in the mode of manipulation; for instance, the difference in the shape of the dishes used, in the quantity of water applied, and in the amount of agitation given to the eggs. In experiments 2, 3, and 4, the dishes were broad and shallow, and the quantity of water liberal. In experiment 6 the dishes were small mugs, and the quantity of water proportionably small. In the case of lot 189, perhaps the stirring given before the milt was applied was insufficient to give the water access to those eggs which lay in the bottom of the mug, and that they, therefore, retained the susceptibility of fecundation for some minutes longer than they would have done if pure water had had free access to them.

6.—THE SUSCEPTIBILITY OF EGGS TO FECUNDATION OUT OF WATER.

Experiment 7.—Lot 67 stood long before milting or watering; rate of fecundation, 100 per cent.

Experiment 8.—Lot 92 stood without milt, while lot 93 was taken and milted; rate of fecundation, 100 per cent.

Experiment 9.—Lots 133 and 134 were kept in a pan half an hour before milt was applied, and the rates of fecundation were 90 and 80 per cent. respectively. In the former case water was applied as soon as usual; in the latter case the eggs, with the milt, were carried without water to the hatching-house, and turned directly into the troughs. This circumstance is not, however, believed to have been influential, for in other cases it was found to make no difference. (See lots 129 to 132, in table 9.) That the eggs themselves were healthy is proved by the successful fecundation of the remainder of the eggs from the same fish, by the ordinary method, the rate in all being 100 per cent.

Experiment 10.—The eggs were taken from a healthy fish, and part of them (lot 210, containing 4,400 eggs) milted at once with complete success. The remainder were kept in the hatching-house in a pan covered over, but not secluded from the air. At the end of twelve hours, thirty hours, two days, and four days, successive lots (225, 229, 234, 250) were taken from this pan, and milted with fresh milt. The rate of fecundation was as follows: at the end of twelve hours, 90 per cent.; thirty hours, 87½ per cent.; two days, 75 per cent.; four days, 12½ per cent.

The results above stated show that the egg retains the susceptibility to fecundation for several days, under favorable circumstances, but that in some cases a considerable percentage loses it in half an hour.

7.—DURATION, IN AIR, OF THE FECUNDATING POWER OF THE MILT.

Experiment 11.—Lot 76: milt taken ten minutes before its application to the eggs; fecundation, 92½ per cent.

Experiment 12.—Lot 85: milt taken from the fish several hours in advance, and kept in an open dish; fecundation, 100 per cent.

Experiment 13.—Lot 249: milt kept four days before application; fecundation, none. This total failure is supposed to have been the fault of the milt, since some of the same eggs treated with freshly-taken milt were fecundated. (See lot 250.)

8.—DURATION, IN WATER, OF THE FECUNDATING POWER OF THE MILT.

Several extensive experiments were undertaken for the purpose of determining this point, but accident frustrated them, and they are not reported. But it may be stated, in general, that milt was found to preserve its efficiency for several minutes after being placed in water.

Doubtless it makes a great difference whether the milt is mixed thoroughly with the water, or is permitted to settle in a body to the bottom, as it will when dropped gently into water. In the latter case the water may not gain access to the main mass of the milt for some time.

9.—DURATION OF CONTACT NECESSARY TO INSURE FECUNDATION.

In the ordinary course of procedure the milt was in contact with the eggs not far from a minute before the application of water, and from twenty minutes to an hour, or even longer, thereafter. In two instances, immediately after the application of the milt and the stirring of the eggs enough to diffuse it among them, it was washed off by rinsing the eggs several times with clean water, the whole being done with the utmost possible dispatch.

Experiment 14.—Lot 125, containing 3,300 eggs; the eggs were rinsed with clean water immediately after milting; fecundation, 100 per cent.

Experiment 15.—Lot 127, containing 2,700 eggs; rinsed immediately after milting; fecundation, 100 per cent.

From this it appears that fecundation is effected so quickly that, for practical purposes, it may be considered instantaneous.

10.—TEMPERATURE OF WATER AND DEVELOPMENT OF EGGS.

The temperature of the water in the hatching-house when the first eggs were deposited, was 44° F., and they developed rapidly. On the 3d day of November it had fallen to 42°, and from that time till the 16th it vibrated between 42½° and 39°. On the 20th it sunk to 37°, and on the 21st to 35°. About this point it remained until the last week in December, when it sunk to 33°, the temperature of the air outside being —19°. During the rest of the winter it generally stood at 33½° or 34°, occasionally rising to 36°. In the spring it sunk instead of rising, the water being colder during the first half of April than at any other time during the season. This I attribute to the abundance of snow and ice-water running into the brook at that time. No difficulty was experienced in keeping the building warm enough to avoid any injurious freezing, although on several occasions, when the night was extremely cold and the fires dull, ice formed in some of the troughs.

In this extremely cold water, of course the development of the eggs was very slow. In the first lot the heart of the embryo was beating December 16, but the eyes were not black until January 9, seventy-three days from fecundation. In spring-water the same stage would be reached in about thirty days. On the 7th day of February the circulation was barely established in the embryos taken November 21. In those taken November 14 it was distinct and the embryos active; in those of November 9 the circulation was stronger and the embryos larger, but there was still no sign of color in the eyes, although ninety days had passed since fecundation. The only disadvantage in this slow

development is the additional expense attending it, and I think this is fairly counterbalanced by the longer time afforded for packing up and distributing the eggs, and by having the hatching delayed until the natural period, when all the conditions existing in the water may be supposed to be best adapted to the healthy growth of the young fish. The water in the streams where salmon naturally spawn is quite as cold as that used in this hatching-house, and the incubation of eggs there goes on quite as slowly. During incubation one man can, under ordinary circumstances, take care of several millions of eggs. There is little to be done except to pick out those that die and turn white, before they decay and contaminate the water. In water of 34° F. decay begins so tardily that once a week is often enough to take out the dead eggs. This was done in the present case with wire-pointed wooden pliers, without removing the trays from the trough. Some fish culturists remove the trays to a table, where the work can be done easier, but my own experience leads me to believe that at certain stages of development the eggs will not endure the disturbance involved without injury.

The number of dead eggs taken from the troughs was not larger than ordinary until about the 1st of January. At that time the number dying from day to day suddenly increased, and was very large during the rest of the season. The percentage lost in this way at Orland the previous season was but a little over 2 per cent. of the number of eggs taken. At the same rate the number this year should have been only about 32,000. Actually it reached the large total of about 318,000 or 20 per cent. of the whole. This extraordinary mortality requires explanation. It was due to a variety of causes. First, the windows had been curtained only with cotton cloth, and this admitted an amount of light that encouraged the rank growth of a species of confervoid vegetation which spread over the eggs like a blanket, shutting them out from a due supply of water from the current flowing above them, and exposing them to the influence of the water beneath the trays. Second, the space underneath the trays was too narrow for so long troughs as 60 feet; there was little or no current through it, and the *conferva* prevented a circulation through the trays. Thus this space was occupied by stagnant water, which soon became surcharged with noxious substances, the exudations from the wooden troughs and the decay of eggs that accidentally slipped down beneath the trays, playing an important part. With a suitable current of water all these injurious substances would have passed off before they had accumulated sufficiently to do harm. But in the stagnant water they rapidly accumulated, and, coming in contact with the eggs above them, destroyed them by thousands. Third, a long stove-pipe ran above one of the troughs; the liquid condensed within it in cold weather was carried away in a gutter, but on several occasions considerable quantities of this poisonous liquid found its way into the troughs.*

* The causes second and third might have been avoided by the use of covers to the troughs, and these have since been made.

The first difficulty was remedied by darkening the windows, which was soon followed by the entire disappearance of the *conferva;* the second by raising the trays so as to establish a current underneath them. By prompt action the eggs that had not yet been affected were saved, but a large proportion of those that retained life long enough to be packed up and sent away had been so seriously injured as to perish, either during incubation or soon after hatching.

11.—PACKING AND SHIPMENT AND DISTRIBUTION OF EGGS.

During the early part of the season of incubation, with the co-operation of Mr. E. A. Brackett of the Massachusetts commission, I tried a series of experiments designed to determine the period when salmon eggs can be transported with safety. Ten successive packages, each containing eggs from five separate lots of widely different ages and stages of development, were sent by express to Winchester, Mass., where Mr. Brackett unpacked them and noted the result. The first package was sent on the 14th of November, and the last on the 7th of January. The results observed were very uneven, almost total loss attending some shipments, while in others the average ratio of loss was quite small. In the first two packages, the germ of the oldest eggs was in process of expansion over the surface of the yolk, while in the youngest eggs that process had not begun; in the former the loss was several fold greater than in the latter. In the second package the percentage of loss in the several lots, beginning with the oldest and running down to the youngest, was as follows: 62, 45, 36, 21, zero. In the third lot it was 20, 8, 8, 2, 8. In the fourth lot, the development was but little advanced over the former ones, and the percentage of loss in the several lots remained substantially the same, being, in the order of the age of the lots, 88, 84, 10, 8, zero. The next two packages were badly frozen, and the result therefore indecisive. On the 17th of December, another package was sent, in which the oldest eggs were so far advanced that the heart of the embryo could be seen beating, while the younger eggs had arrived at the same stage as the older ones had in the earlier packages. The relative losses were now reversed, the percentage being from oldest to youngest, zero, zero, 2, 42, 2. A week later another package resulted as follows: percentage, zero, zero, 36, 8.

The general conclusion drawn from the result of these experiments was this: that the critical period, during which salmon-eggs cannot be transported without danger of great loss, begins with the first expansive movement of the germ, and ends with the establishment of the circulation. In our earliest eggs this period was, approximately, from the fifteenth day after fecundation to the thirty-fifth day, ending thirty-seven days before the appearance of black eyes. In the later lots, owing to the lower temperature of the water, it was long deferred. In water having a uniform temperature of 44° F. I should think the critical period would begin as early as the tenth day from fecundation, and last two weeks.

Either before or after this period, eggs can be transported with much greater safety, although I do not think it yet established that any time is quite so favorable as that succeeding the first appearance of dark color in the eyes.

The general shipment of eggs began February 3d, and continued weekly until late in the spring, the last lot being sent away in April. The whole number distributed was 1,291,800. There were retained and hatched at Bucksport about 150,000 eggs, being part of the share falling to the lot of Maine. The remainder, 1,091,800, were packed up in moss and sent away; 152,000 going on a sled to Bangor and thence by rail to Dixfield, Me.; the rest all going from Bucksport to Boston by steamer, and from that point by rail to their several destinations.

Several modes of packing were adopted. The first was the use of trays similar to the hatching trays in use at Bucksport, made of iron wire cloth with wooden frames around the edges. One or two layers of eggs were placed on each tray, with layers of sphagnum-moss below, above, and between them. In most cases pieces of mosquito-netting were spread beneath and above each layer of eggs, between them and the moss, for convenience in unpacking, the trouble of separating the eggs from the moss when nothing intervenes being very great. After packing, the trays are set, one on another, in a box large enough to receive them; the frames, coming in contact, sustain all the weight, entirely relieving the eggs from any pressure except such as the packer may choose to give them; this box is then inclosed in a larger one, with saw-dust, tow, or some other non-conductor of heat, to protect against extremes of temperature. This mode of packing is very economical of space, and thus far appears to be safe, unless the eggs and moss be placed in the tray so loosely as to slide down together to one side if the box be placed in any other than an upright position. The second method is the use of cylindrical tin boxes about five inches deep and six inches in diameter, in which the eggs are placed in layers alternating with layers of moss. Each layer of eggs lies between two disks of mosquito-netting sewed to brass rings of just the right size to go into the box easily. Six or eight layers of eggs, numbering from 1,600 to 3,000 eggs, are placed in each box. The tins are then placed, as in the other method, in a large box, with a protective packing. I prefer this mode to any other for long distances, and all the eggs sent to the Middle and Western States were so packed. Some of the parties receiving the eggs objected to the size of the boxes and the pressure that the eggs sustained in them; but I think that the loss which they attributed to this cause was really the result of the general injury of the eggs, in the troughs at Bucksport, as explained above. In all cases sphagnum-moss, gathered from bogs, without any special care to keep out dirt, was used, and excess of moisture, more than the moss could hold without dripping, avoided.

The eggs hatched out for the State of Maine, in the Bucksport hatch-

ing house, numbering about 150,000, suffered a loss of 62,500 during incubation, being 41.66 per cent. A very few of them hatched in March, but the fall of temperature in April retarded the others, so that but a small number of fish came out until the last week in April. The temperature then rose from 34° to 40°. On the thirteenth day the hatching was at its height, and before the 10th of May all the eggs were hatched. The distribution of the young fish took place the 1st of June, the absorption of the yolk-sack being then complete. In the preliminary trials at transportation 10,500 salmon were lost. The remaining 77,000 were turned alive into the Penobscot and Saint Croix Rivers, the former receiving 67,000 and the latter 10,000. The remainder of the eggs allotted to Maine, to the number of 152,000, were transported to Dixfield, Oxford County, and hatched by Mr. Stanley, of the board of commissioners, in spring-water. The fish came out early, with a loss of about 22,000, or about 15 per cent., leaving 130,000. These, after a loss not reported, were all set free in the Androscoggin River and its tributaries.*

The eggs sent to New Hampshire numbered 21,400, the loss in incubation was between 30 and 40 per cent., and the young fish were placed in the head-waters of the Merrimac, about the time the sack was absorbed.†

To Vermont were allotted 10,000 eggs. They were hatched by Seth Green, at Rochester, New York, with a loss of 30 per cent., and the fish placed in the Winooski and Lamoille Rivers, tributaries of Lake Champlain.‡

Massachusetts received 232,800. They were hatched out by Mr. E. A. Brackett, of the board of commissioners, at Winchester, in spring-water. The loss in incubation was about 24 per cent., amounting to 55,800. The young fish were healthy and vigorous; 165,000 of them were placed in the head-waters of the Merrimac, soon after the absorption of the yolk-sack; and into the Mystic River and Red Brook, about 11,000 each.§

The share of Rhode Island numbered 100,000 eggs. They were hatched at Poneganset, by Mr. J. H. Barden, of the board of commissioners, in water of 46° F. The total loss was 36,000, being 36 per cent. The 64,000 young fish obtained were distributed in the Blackstone, Pawtuxet and Pawkatuck Rivers. They appeared strong and healthy.||

To Connecticut were sent 264,000 eggs; 204,000 of them were hatched at Poquonnoc, by Mr. Clift; 50,000 at North Branford, under the auspices of the Waltonian Society, of New Haven, and 12,000 at Westport. The eggs sent to Poquonnoc suffered a loss of 20,200 in transportation and unpacking, and a further loss during incubation of 33,175, leaving

* Distribution in detail as follows: into Swift River, 30,000; into Rangely Lake, a few thousand; into the Androscoggin and tributaries, near Dixfield, the remainder. Letter of H. O. Stanley.)

† Letter of W. W. Fletcher.

‡ Letter of M. C. Edmunds.

§ Letter of E. A. Brackett.

|| Letter of J. H. Barden.

151,625, which hatched out. The rate of mortality was very uneven among these eggs, in some lots being as high as 75 per cent., and in others as low as 6 per cent. The eggs sent to Westport and North Branford suffered an equal loss with the above. The young fish, numbering in the aggregate, at all the establishments, 198,000, were set free as soon as the absorption of the yolk-sack was complete, in various streams in Connecticut.*

William Clift, of Mystic Bridge, Conn., agent for the Poquonnoc Fish-breeding Company, received 64,000 eggs. A small number of them were sold, and the remainder hatched at Poquonnoc, with a loss of 33 per cent. The young fish were turned into Great Brook, which the company is trying to stock with migratory fishes as a private venture. The foreman of this establishment, Mr. A. A. Anderson, reported the young fish from these and the eggs belonging to the State, under his charge, as uniformly weaker on first coming out than any salmon fry he had ever seen. Afterward, however, they looked better.

To New York there were allotted, from the share belonging to the United States, 80,000 eggs. They were sent to Seth Green, Rochester, and hatched at the State establishment. The loss was 26,000, † being 32½ per cent.; 25 per cent. of this occurred during incubation, and the rest soon after. As soon as the yolk-sack was absorbed the young fish were set free; 24,000 of them were placed in tributaries of the Hudson; 15,000 in tributaries of Salmon River; and 15,000 in a tributary of the Oswego.

New Jersey received 40,000 eggs, which turned out to be in a condition much better than average. They were hatched out at Dr. J. H. Slack's establishment at Bloomsburg. Only 10 per cent. were lost in incubation. Of the 36,000 young fish, the Delaware River received 18,000, the Raritan 15,000, and 3,000 were sent to Long Island.‡

Pennsylvania was awarded 40,000 eggs. They were received by Mr. Thaddeus Norris, of Philadelphia, who had made arrangements to have them hatched at private expense, at Heitzman's Springs two miles above Easton, on the New Jersey side of the Delaware. On unpacking these eggs they appeared in remarkably fine condition, but the average mortality attended them before they hatched, 37½ per cent. or 15,000 eggs perishing.§ The remainder, 25,000, produced fish, which were turned into the Delaware River.

There were sent to Dr. E. Sterling, of Cleveland, Ohio, a small package of eggs, numbering 5,200. They were hatched by Mr. John Hoyt, at the Castalia Springs, near Sandusky. The loss in incubation was 2,700,

* For further details of distribution see Table 11.

† Mr. Green attributed the loss in great part to the large size of the tins in which the eggs were packed, which caused too great pressure on the lower layers.

‡ Dr. Slack reports 18,000 put into the Delaware, 18,000 put into the Raritan, and 3,000 sent to Long Island, making 39,000 in all, which exceeds the number of fry computed above by 3,000. This discrepancy might come from an error in counting either eggs or fry.

§ Letter of T. Norris.

or 52 per cent. The remaining eggs produced 2,500 young salmon, and they were turned into the Castalia Ponds, which discharge by a stream, three or four miles long, into Sandusky Bay. The water of these ponds, and of the springs which supply them, is very warm, between 50 and 60 degrees,* is of remarkable transparency, and highly charged with mineral matter in solution.

The eggs sent to Michigan numbered 43,200. They were received by N. W. Clark, who hatched them out for the Commissioners of Fisheries, at Clarkston. The eggs were packed up March 10, and despatched on the 11th, but did not reach their destination until the 17th. Not over 5 per cent. of them were found dead on unpacking.† The temperature of the water was 34° F. at the time the eggs were placed in the boxes, and it continued about the same until March 25, after which it grew gradually warmer until it attained the ordinary summer temperature of 60° F. The fish were all out about the middle of April, to the number of 30,000, there having been a loss of 30 per cent. in hatching. The distribution of the young commenced May 14, the number having meanwhile become reduced to 19,500, making a total loss of 23,700, or 55 per cent. The 19,500 fish distributed were put into the Kalamazoo, Saint Joseph, Grand, Muskegon, and Manistee Rivers, tributary to Lake Michigan, and the Au Sauble River, tributary to Lake Huron, also into Orchard, Walled, Whittemore, Diamond, and a few smaller lakes. Some of them are reported to have been since seen in Diamond Lake in good condition.

The eggs awarded to Wisconsin, 40,724, were sent by express in three packages, that were dispatched as follows, viz: 9,324 February 24; 18,400 March 3; and 13,000 March 10. In the first package 100 eggs died on the way; in the second 350; and in the third 1,000; in all 1,450. The subsequent loss in eggs and newly-hatched fry was about 19,500. There were hatched and saved about 19,000 fish. The first of them came out on the 13th of March, and all were out the first week in April. The hatching was conducted by Mr. H. F. Dousman, at Waterville, Waukseha County, in spring-water having a temperature of 48° F. Early in the spring the young salmon were distributed; 7,000 were put into Menomonee River, tributary to Green Bay; 1,000 into Oconomowoc Lake; and 11,000 into Milwaukee River. The latter were intended for the Kewaunee River, which lies one hundred miles farther north, but an ice blockade compelled the change.‡

* Letter of John Hoyt.

† Letter of N. W. Clark. Mr. Clark remarked that the large cans contained more dead eggs than the small ones, and concluded that the pressure on the under layers, consequent on the large size of the boxes, caused the injury.

‡ Letter of H. F. Dousman. Mr. Dousman reports that one of these fish is supposed to have been caught late in August, on the Menomonee River, one hundred and fifty miles above its mouth, by one Cruickshank, a native of Nova Scotia, who was acquainted with the species and pronounced the fish a salmon, on the strength of its appearance and taste, ignorant of the fact that young salmon had been distributed there. The specimen was estimated to weigh 6 ounces.

Thus it appears that the young salmon set free as the net product of the season's work was 876,000, being 71 per cent. of the eggs distributed, and 57 per cent. of those originally taken from the fish. This result, though it compares favorably with previous operations of the kind both in this country and abroad,* is far below what may be expected under favorable circumstances. When the influences that occasioned the serious injury to the eggs during their development at Bucksport are avoided, as they evidently can be, there seems no reason to doubt that the aggregate losses can be reduced to 10 or 15 per cent. of the eggs taken from the fish. The latter number can also be largely increased by improvement in the mode of handling and transporting the adult salmon, and the use of more efficient means for recapturing them in the fall. That there is room for improvement does not, however, alter the fact that the season's operations were positively successful, and, moreover, successful to an extent which, for the first time, placed in the hands of the commissioners having the matter in charge adequate material for the re-establishment of broods of salmon in the exhausted rivers of New England.

C—TABULAR STATEMENTS EMBODYING OBSERVATIONS ON SALMON AND SALMON RIVERS IN MAINE.

The following tabular statements embody nearly all the facts observed in connection with the breeding of salmon on the Penobscot River.

In regard to the records of temperature, it should be stated that the observations were made with ordinary instruments, and, for the most part, by persons little accustomed to their use. Yet the results in these cases accord so well with my own observations that I have confidence in their general correctness.

TABLE I.—*Record of temperature at Craig's Pond Brook, Orland, Me.*, 1871.

Date.	Temperature, (Fahrenheit.)						Wind.	Remarks.
	Air.		Brook.		Allamoosook Pond.*			
	5½ a. m.	3½ p. m.	5½ a. m.	3½ p. m.	5½ a. m.	3½ p. m.		
1871.								
June 9	60	70	......	61	....		Southwest, heavy	Clear.
10	58	65	52	54	....		Southerly	Cloudy, and rain in p. m.
11	64	......	52	......	....		....	
12	56	66	52	52	....		Calm	Rain.
13	60	65	51	55	....		....	A. m. clear; p. m. rain.
14	56	68	50	54	....		Calm	Cloudy; showers.
15	60	74	51	56	....		Southwest, heavy......	Shower.
16	62	65	50	54	....		Southwest	Cloudy.

* Taken near the surface, in the pound where the salmon were confined.

*At the famous fish-breeding establishment at Hüningen, during the season of 1871–'72, the first year of the German management, out of two and a half millions of eggs collected, one million were lost before they were distributed, and it is stated on good authority that the loss was equally great while the establishment was under French control. [R. Hessel, MSS.]

TABLE I.—*Record of temperature at Craig's Pond Brook, Orland, Me.*, 1871—Continued.

Date.	Temperature, (Fahrenheit.) Air. 5½ a. m.	Air. 3½ p. m.	Brook. 5½ a. m.	Brook. 3½ p. m.	Allamoosook Pond. 5½ a. m.	Allamoosook Pond. 3½ p. m.	Wind.	Remarks.
1871.								
June 17	50	74	50	55	......	......	North	Clear.
18	62	65	50	54	......	......	Southwest	Cloudy.
19	60	75	50	55	......	......	Calm	Do.
20	65	80	50	56	......	......	West	Clear.
21	60	84	50	55	......	......	North	Do.
22	51	80	50	55	......	......	....do	Do.
23	54	83	50	55	......	......	....do	Shower.
24	52	67	50	54	......	......	Northwest	Clear.
25	52	70	50	55	......	......	....do	Do.
26	64	84	50	56	......	......	....do	Do.
27	60	76	50	53	......	......	South	Do.
28	60	65	......	......	60	60	Southeast	Cloudy.
29	64	76	......	......	65	70	South	Do.
30	54	75	......	......	65	68	Northwest	Clear.
Sums ...	1284	1527	908	989	......	......		
Means ..	58.2	72.7	50.4	54.9	......	......		
July 1	52	76	......	......	68	70	South	Clear.
2	52	75	......	......	65	68	South-southwest	Do.
3	58	60	......	......	64	75	North	
4	60	80	......	......	70	77	....do	
5	61	82	......	......	70	77	Calm	
6	62	84	......	......	70	78	Southwest	
7	61	82	......	......	74	78	South-southwest	
8	60	77	......	......	70	77	North	
9	68	80	......	......	70	76	South	
10	70	80	......	......	70	78	North	Clear.
11	68	80	......	......	70	72	....	Cloudy; rain.
12	70	82	......	......	70	75	Calm	Clear.
13	62	82	......	......	74	80	....do	
14	64	80	......	......	74	76	Southwest, strong	
15	68	74	......	......	72	76	....do	
16	68	80	......	......	75	75	North	Clear.
17	67	76	......	......	72	78	West	Shower.
18	72	75	......	......	70	73	Southwest	Do.
19	65	74	......	......	70	72	....do	
20	65	78	......	......	70	70	Northeast	Rain.
21	56	75	......	......	70	70	Southwest	Clear.
22	55	75	......	......	70	70	Southeast	Cloudy.
23	58	76	......	......	72	74	North	Clear.
24	65	76	......	......	75	77	Southwest	Do.
25	60	72	......	......	75	74	.... do	Cloudy.
26	60	70	......	......	65	74	East and southeast	Do.
27	62	76	......	......	65	78	Southwest	Do.
28	64	78	......	......	70	82	....do	Clear.
29	64	80	......	......	75	82	Southeast	Cloudy.
30	65	78	......	......	72	80	....do	Do.
31	66	68	......	......	74	76	Calm	Do.
Sums ...	1948	2481	......	......	2191	2338		
Means ..	62.8	80	......	......	70.7	75.4		
Aug. 1	68	68	......	......	72	72	Southwest	Clear.
2	66	80	......	......	72	80	West	Do.
3	65	80	......	......	69	78	Southwest	Do.
4	64	79	......	......	72	82	Northwest	Do.
5	70	75	......	......	72	74	....	Cloudy; shower.
6	75	76	......	......	72	74	....	
7	60	80	......	......	70	75	South	
8	65	70	......	......	71	72	....do	Cloudy.
9	68	84	......	......	72	72	Northwest	Clear.
10	59	68	......	......	70	72	....do	Do.
11	62	80	......	......	70	76	....do	
12	62	82	......	......	72	78	....do	Clear.
13	58	72	......	......	70	76	....do	Do.
14	54	78	......	......	70	72	....do	Do.
15	58	80	......	......	70	76	South-southwest	Do.
16	60	68	......	......	71	76	....	Fog.
17	65	84	......	......	70	77	Northwest	Clear.
18	49	72	......	......	70	72	Southwest, heavy	Do.
19	54	76	......	......	70	76	Northwest	Do.

TABLE I.—*Record of temperature at Craig's Pond Brook, Orland, Me.*, 1871—Continued.

Date.	Temperature, (Fahrenheit.) Air.		Brook.		Allamoosook Pond.		Wind.	Remarks.
	5½ a. m.	3½ p. m.	5½ a. m.	3½ p. m.	5½ a. m.	3½ p. m.		
1871.								
Aug. 20	56	72	......	......	64	72	Northwest	Clear,
21	56	78	......	......	68	76	....do	Do.
22	48	80	......	......	68	76	Southwest	Do.
23	50	78	......	......	69	76	Southwest, heavy	Do.
24	54	76	......	......	68	74	......	
25	60	90	......	......	70	76	Calm	
26	50	80	......	......	66	70	....do	
27	60	67	......	......	70	70	....do	
28	60	80	......	......	66	70	Northwest	Cloudy.
29	60	70	......	......	70	70	South-southeast	Do.
30	62	70	......	......	70	72	South	Do.
31	60	78	......	......	68	75	Southwest	Clear.
Sums ...	1858	2371	......	......	2162	2307		
Means ..	59. 9	76. 5	......	......	69. 7	74. 4		
Sept. 1	52	76	......	......	70	74	North	Clear.
2	58	64	......	......	64	66	....do	Rain.
3	60	66	......	......	65	65	South	Clear.
4	64	78	......	......	65	70	....do	Do.
5	60	78	......	......	65	72	Southwest	Do.
6	74	78	......	......	70	74	....do	Foggy.
7	74	76	......	......	70	74	....do	Do.
8	48	64	......	......	64	66	North	
9	50	66	......	......	58	66	South	
10	58	67	......	......	62	66	Calm	Clear.
11	48	72	......	......	62	70	West	Do.
12	44	65	......	......	62	68	Southeast	Do.
13	58	70	......	......	60	69	North	Do.
14	40	66	......	......	59	65	....do	Do.
15	32	60	......	......	60	64	Southeast	Do.
16	52	58	......	......	60	62	......	Rain.
17	56	58	......	......	60	62	......	Overcast.
18	44	62	......	......	60	62	North	Clear.
19	56	60	......	......	60	60	South	Cloudy.
20	58	62	......	......	60	61	North	Clear.
21	52	60	......	......	58	60	....do	Do.
22	32	60	......	......	56	61	....do	Do.
23	44	60	......	......	60	60	Southeast	Do.
24	50	58	......	......	56	60	North	Do.
25	44	60	......	......	58	60	Southeast	Do.
26	48	58	......	......	60	60	....do	Cloudy.
27	58	62	......	......	57	60	....do	Do.
28	52	58	......	......	60	60	....do	Do.
29	42	57	......	......	60	60	North	Clear.
30	42	56	......	......	57	59	....do	Do.
Sums ...	1550	1935	......	......	1838	1936		
Means ..	51. 6	64. 5	......	......	61. 2	64. 5		
Oct. 1	42	56	......	......	58	58	Southwest	Clear.
2	50	56	......	......	58	58	....do	Do.
3	50	55	......	......	58	58	....do	Do.
4	54	56	......	......	58	58	....do	Do.
5	50	60	......	......	56	60	....do	Do.
6	58	64	......	......	59	60	....do	Cloudy.
7	54	64	......	......	60	60	Northwest	Do.
8	42	63	......	......	54	60	North	Clear.
9	44	60	......	......	58	60	......	Clear in afternoon.
10	56	58	......	......	58	60	West	Clear.
11	59	64	......	......	60	60	South	Cloudy; showers.
12	65	63	......	......	60	60	Southeast	Do.
13	42	67	......	......	58	61	Northeast	Clear.
14	50	62	......	......	59	60	....do	Cloudy.
15	55	62	......	......	58	58	South	Do.
16	50	60	......	......	56	58	Northwest	Clear.
17	34	......	......	......	54	......	......	
18	42	55	......	......	56	60	North	
19	35	54	......	......	54	59	South	

TABLE I.—*Record of temperature at Craig's Pond Brook, Orland, Me.*, 1871—Continued.

Date.	Temperature, (Fahrenheit.)						Wind.	Remarks.
	Air.		Brook.		Allamoosook Pond.			
	6 a. m.	4 p. m.	6 a. m.	4 p. m.	6 a. m.	4 p. m.		
1871.								
Oct. 20	44	40			56	58	North	
21	23	38			50	56		
22	22	40			52	52	South	
23	40	60			50	54		
24	40	52			50	55		
25	30				48			
26	48				50			
27	48				50			
28	50				49			
29								
30	38				49			
Sums	1315	1309			1596	1343		
Means	45. 3	56. 9			55	58. 4		
Nov. 1	40				60			
2	41				58			
3	35				56			
4	40		45					
5	34		46					
6			46					
7			45					
8			45					
9			45					
10			44					
11			44					
12			44					
13	22	36	44					
14	25		44					
15			44					
16			44½					
17			46					
18			46½					
19			45					
20			44					
21			44					
22			44					
23			40					
25			41					
26			40					
27			42					
28	3		41					
29	5		42					
30	8		41					
Sums			1137					
Means			43. 7					
Dec. 1	9		40					
2	16		41					
3			41					
4	38		43					
5	8		41					
6	14		39					
7	16		40					
8	19		40					
9	20		41					
10	24		42					
11	20		41					
12	0		40					
13			40					
14			41					
15	1		40					
16	0		40					
Sums	183		650					
Means	14		43. 7					

TABLE II.—*Record of temperature at Salmon Pond, Bucksport, Me., in* 1872.

Date.	Temperature of the air.					Temperature of water. Bottom.*					Temperature of water. Surface.					Wind.	Remarks.
	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.		
1872.																	
June 20	52	61	71	60	64	60	60	60	..	60	71	72	72	71	71. 7	Southwest	Clear.
21	51	52	70	60	60. 7	60	60	60	..	60	70	71	72	72	71. 7	Southerly, brisk	Foggy morning, then clear.
22	56	62	80	68	70	60	60	61	69	60. 3	61	70	79	73	74	Northwest in morn'g.	
23	60	62	74	60	65. 3	60	61	61	61	61	70	71	80	80	77	Southerly...........	Foggy.
24	60	61	70	60	63. 7	60	61	61	60	60. 7	71	71	72	76	73	Southwest	Fogs and clouds.
25	56	59	74	61	64. 7	60	61	61	60	60. 7	68	71	76	70	72. 3	Southe'st to southw't	Do.
26	51	62	70	60	64	60	62	60	61	61	65	71	72	72	71. 7	Southeast...........	Cloudy.
27	60	61	68	60	64	60	60	61	60	60. 3	70	71	73	72	72	Southerly...........	Do.
28	58	59	64	59	60. 7	60	61	61	60	60. 5	68	70	72	71	71	....do	Foggy.
29	58	59	80	60	66. 3	60	60	61	60	60. 3	68	70	78	70	72. 7	....do	Foggy, then clear.
30	58	63	90	68	73. 7	61	62	62	61	61. 7	72	73	79	74	75. 3	....do	
Means ..	..	..	..	..	65. 2	..	..	..	..	60. 6	..	..	..	..	72. 9		

Date.	Temperature of the air.					Temperature of water. Bottom.					Temperature of water. Surface.					Wind.	Remarks.
	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.		
1872.																	
July 1	61	68	89	72	76. 3	60	61	63	61	61. 7	72	73	81	75	76. 3	Variable	Cloudy.
2	57	60	78	67	68. 3	60	60	61	60	60. 3	65	69	76	75	73. 3	Northeast	Do.
3	60	61	61	58	60. 7	60	60	60	60	60	68	68	71	72	70. 3	Southeast...........	Hazy.
4	60	62	62	72	65. 3	60	62	61	62	61. 7	67	78	70	72	73. 3	....do	Cloudy; heavy thunder-shower.
5	63	70	81	72	74. 3	60	60	61	61	60. 7	70	76	72	71	73	Easterly	
6	68	72	80	74	75. 3	61	61	61	61	61	72	73	74	71	72. 7	Northwest	Clear.
7	69	71	81	72	74. 7	61	61	62	61	61. 3	70	72	78	71	73	Southwest	Do.
8	68	70	79	64	71	61	61	61	61	61	72	73	73	70	72	Variable	Do.
9	60	63	72	68	67. 7	60	60	61	61	60. 7	70	71	73	70	71. 3	Southwest, brisk....	Do.
10	68	69	71	66	68. 7	60	60	60	60	60	72	72	72	70	71. 3	Southwest	Foggy morning.
11	73	74	78	76	76	60	60	60	60	60	75	76	73	75	74. 7	Westerly	
12	69	73	78	63	71. 3	60	60	61	60	60. 3	73	75	73	72	73. 3	Variable	
13	61	65	76	64	*8. 3	60	60	60	60	60	70	72	72	72	72	Northwest	Clear.
14	62	63	74	60	65. 7	65	65	65	65	65	70	74	74	73	73. 7	Southerly...........	Do.
15	60	62	76	62	66..7	67	67	67	67	67	71	72	73	72	72. 3	Southeast..........	Fog.
16	70	73	80	71	74. 3	68	68	70	70	69. 3	72	73	78	74	75	Southerly...........	Clear.
17	75	76	78	70	74. 3	70	70	70	70	70	73	73	76	73	74	Southeast...........	Cloudy.
18	60	63	63	60	62	70	70	70	70	70	73	74	76	73	74. 3	... do	Fog and clouds.
19	60	61	85	65	70. 3	71	71	71	71	71	73	73	78	73	74. 7	Southwest	Rain.
20	61	68	80	65	71	71	71	71	71	71	73	73	76	72	73. 7	Northwest	Clear.
21	61	68	75	68	70. 3	71	71	71	71	71	72	73	76	75	74. 7	Southwest	Do.
22	56	58	61	69	62. 7	71	71	71	70	70. 7	72	72	72	73	72. 3	Southerly...........	Rain.
23	56	58	70	60	62. 7	68	68	71	70	69. 7	70	70	73	71	71. 7	Northwest	
24	60	63	71	65	66. 3	70	70	70	70	70	71	72	74	73	73	Southerly...........	Rain.
25	62	68	78	68	71. 3	71	71	71	71	71	72	75	76	76	75. 7	Northwest	Clear.
26	58	60	65	60	61. 7	71	71	71	71	71	73	73	73	72	72. 7	Southeast...........	Cloudy.
27	56	58	62	60	60	68	68	70	70	69. 3	70	70	71	70	70. 3	Northwest	Rain in morning.
28	58	60	68	64	64	68	68	71	70	69. 7	70	70	74	73	72. 3	....do	Clear.
29	59	60	70	68	66	68	70	71	70	70. 3	70	71	73	72	72	Variable	Cloudy and showers.
30	55	58	70	65	61	67	67	71	70	69. 3	69	70	73	73	72	Northwest	
31	57	59	68	63	63. 3	68	70	70	70	70	70	73	74	72	73	Westerly	Clear.
Means ..	..	..	..	..	68. 1	..	..	..	.	65. 9	..	..	..	..	73. 1		

* The observations on the bottom temperature were obtained by sinking a closed tin can to the bottom and keeping it there at all times except at the moment of observation, when it was drawn up, the cover removed, and the bulb of the thermometer inserted in the water. The depth at the point of observation was from eight to ten feet. The surface temperature was measured at the same place as the bottom temperature, and the position was changed several times during the summer.

TABLE II.—*Record of temperature at Salmon Pond, Bucksport, Me., in* 1872—Continued.

Date.	Temperature of the air.					Temperature of water. Bottom.					Temperature of water. Surface.					Wind.	Remarks.
	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.		
1872.																	
Aug. 1	60	62	70	58	63. 3	68	68	71	70	69. 7	70	70	73	72	71. 7	Northwest	Clear.
2	60	63	70	59	64	65	68	70	70	69. 3	70	72	73	71	72	Southwest	
3	55	52	63	59	58	60	68	70	70	69. 3	68	70	72	71	71	Southeast	Fog and showers.
4	56	60	60	58	59. 3	68	70	70	70	70	70	72	73	71	72	Northwest	Cloudy.
5	58	61	63	57	60. 3	67	70	70	70	70	70	71	72	71	71. 3	Variable	Clear; rain ½ inch.
6	60	63	72	68	67. 7	68	70	70	70	70	71	74	75	71	74	Southerly	
7	58	60	68	65	64. 3	60	61	70	70	67	69	70	72	71	71	Southeast	Foggy morning.
8	59	60	70	67	65. 7	60	62	71	71	68	68	70	73	72	71. 7	....do	Fog and clouds.
9	62	68	70	68	68. 7	70	70	71	70	70. 3	72	74	75	74	74. 3	....do	Clear.
10	60	63	72	69	68	68	69	70	70	69. 7	70	70	73	72	71. 7	....do	Do.
11	68	70	78	72	73. 3	71	71	70	71	70. 7	70	74	75	73	74	....do	Cloudy; rain ½ inch.
12	67	69	70	70	69. 7	70	70	70	70	70	72	73	75	73	73. 7	Southerly	Cloudy.
13	68	69	72	67	69. 3	70	70	70	70	70	73	74	74	72	73. 3	Southeast	Rain ½ inch.
14	68	71	76	68	71. 7	70	71	71	71	71	72	76	77	74	75. 7	Southwest	Foggy.
15	63	65	67	68	66. 7	70	70	70	70	70	72	73	74	73	73. 3	Southeast	Cloudy.
16	68	70	73	68	70. 3	70	70	70	70	70	73	74	75	73	74	Northeast	Do.
17	67	68	70	69	69	70	70	70	70	70	73	74	73	72	73	Southerly	Rain 1 inch.
18	67	69	73	69	70. 3	70	70	70	70	70	74	75	76	73	74. 7	Southeast	
19	67	78	85	72	78. 3	70	70	71	70	70. 3	73	74	78	78	76. 7	Variable	
20	67	78	83	72	77. 7	70	71	71	71	71	73	76	75	75	75. 3	Northwest	Clear.
21	68	79	70	68	72. 3	70	70	70	70	70	74	75	75	75	75	Southeast	Foggy.
22	65	68	69	67	68	70	70	70	70	70	73	73	74	74	73. 7	....do	Rain ½ inch.
23	67	68	70	67	68. 3	70	70	70	70	70	73	74	74	73	73. 7	Northwest	Clear.
24	64	66	67	68	67	70	70	70	70	70	74	75	74	73	75	Southerly	Do.
25	66	71	73	69	71	70	70	70	70	70	76	78	76	74	76	....do	
26	68	70	78	70	72. 7	70	70	70	70	70	77	78	78	74	76. 7	....do	
Means	..	..	..	..	68. 3	..	..	..	..	69. 8	..	..	..	..	73. 6		

Date.	Temperature of the air.					Temperature of water. Bottom.					Temperature of water. Surface.					Wind.	Remarks.
	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.		
1872.																	
Sept. 17	..	61	..	..	....	..	63	..	..	..	..	68	..	..	..	Variable	Cloudy.
18	..	63	..	..	....	..	63	..	.	..	..	67	..	..	..	Southerly	Do.
19	..	62	..	..	....	..	63	..	..	..	..	66	..	..	..	Southeast	Cloudy; rain.
20	..	59	..	..	....	..	61	..	..	..	..	63	..	..	..	Westerly	Cloudy; rain 1 inch.
21	..	63	..	..	....	..	60	..	..	..	..	65	..	..	..	....do	
22	..	61	..	..	....	..	60	..	..	..	..	64	..	..	..	Southerly	Clear.
23	..	60	..	..	....	..	58	..	..	..	..	60	..	..	..	Northwest	Do.
24	..	58	60	..	....	..	57	..	..	..	..	60	..	..	..	Southeast	Thunder-shower.
25	..	58	62	..	....	..	58	..	..	..	..	60	..	..	..	Southerly	Cloudy.
26	..	58	61	..	....	..	57	..	..	..	..	59	..	..	..	Southwest	Rain and fog.
27	..	59	60	..	....	..	58	..	..	..	..	60	..	..	..	Southerly	Cloudy.
28	..	50	60	..	....	..	59	..	..	..	..	60	..	..	..	Northwest	Rain 2 inches.
29	..	60	62	..	....	..	55	..	..	..	..	60	..	..	..	....do	Clear.
30	..	52	60	..	....	..	54	..	..	..	..	59	..	..	..	Southerly	Rain.
Means	..	..	..	..	....	..	59. 0	..	..	..	..	62. 2	..	..	..		

TABLE II.—*Record of temperature at Salmon Pond, Bucksport, Me., in* 1872—Continued.

Date.	Temperature of the air.					Temperature of water. Bottom.					Temperature of water. Surface.					Wind.	Remarks.
	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.		
1872.																	
Oct. 1		58	61				54					59				Southwest	Cloudy.
2		52	60				55					59				Westerly	Rain 1 inch.
3		50	60				59					59				Variable	Clear.
4																Northwest	Do.
5		50	51				53					59				Southwest	Do.
6		42	52				52					59				....do	Cloudy.
7		50	51				51					57				Southeast	Do.
8		50	53				51					57				Westerly	Rain 1¾ inches.
9		43	50				50*					53				Northwest	Clear.
10		42	53				50					52				Variable	
11		40	51				49					50				Northwesterly	Rain ½ inch.
12		31	48				48					49				Variable	Clear.
13		42	50				49					50				Easterly	Rain.
14		50	52				49					50				Southerly	Do.
15		40	51				45					49				Westerly	
16		40					45					48				....do	Cloudy and rain.
17		40	49				49					50				Southerly	Clear.
18		41	50				48					50				Southeasterly	Cloudy; rain.
19		41	51				49					49				Northwesterly	Cloudy.
20		49	52				53					55				....do	Clear.
21		30	53				48					49				Variable	Do.
22		31	53				48					48				Southeasterly	
23		26	28													Variable	Rain.
24		36	40													Northwest	Clear.
25		28	31													Variable	Do.
26		32	34													Easterly	Rain.
27		23	28													Northwesterly	Do.
28		30	35													Northerly	Clear.
29		35	38													Northwesterly	Do.
30		36	39													....do	Do.
31		23	35													....do	Rain.
Means		39. 4	46. 5				50. 3					54. 3					

Date.	Temperature of the air.					Temperature of water. Bottom.					Temperature of water. Surface.					Wind.	Remarks.
	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.	Sunrise.	7 a. m.	1 p. m.	9 p. m.	Mean.		
1872.																	
Nov. 1		30	38														
2		32	37														
3		33	35														
4		30	30														
5		21					39½					38					
6		29					40					32					
7		45					41					41					
8		39					41					41					
9		39					41					41					
10		31					40					40					
11		26					40					32					
12		43					41					40					
13		38					41					41					
14		28					41					41					
15		38					41½					41					
16		23					41					32					
Means		32. 8					40. 7					38. 3					

TABLE III.—*Record of temperature at hatching-house of Penobscot salmon-breeding works, Bucksport, Me.,* 1872 *and* 1873.

Date.	Temperature of air.				Temperature of water.				Wind.	Weather.
	7 a. m.	1 p. m.	9 p. m.	Mean.	7 a. m.	1 p. m.	9 p. m.	Mean.		
1872.										
Nov. 1	30	38	......	......	44	44	44	44	Northeasterly.	Rain.
2	32	37	......	......	44	44	43	43.7	Northeast.....	Do.
3	33	35	......	......	43	43	42	42.7	Northerly.....	Rain and snow.
4	30	37	24	30.3	37	41.5	40	39.5	....do.........	Clear.
5	21	40	28	29.6	37	42.5	41	40.1	....do.........	Do.
6	29	43	44	38.6	40	41	41	40.6	Southerly	Cloudy; rain.
7	45	49	38	44	42	42	42	42	Easterly	Rain .... 2.7 in.
8	39	45	40	41.3	41	42	42	41.6	Southwest	Cloudy ......
9	39	47	39	41.6	41	42	41	41	Westerly......	Cloudy.
10	31	40	32	34.3	40	40	39	39.6	Northwest	Clear.
11	26	40	37	34.3	39	40	39.5	39.8	Southerly	Do.
12	43	47	45	45	40	41	41	40.6	Southeast.....	Cloudy; rain.
13	38	46	33	39	41	42	41	41.3	Westerly......	Clear.
14	28	42	42	37.3	40.5	41	41	40.8	Variable	Rain.
15	38	42	26	35.3	41	42.5	40.5	41.3	Northwest	Clear.
16	23	36	30	29.6	41	40	40	40.3	Southerly.....	Do.
17	26	37	23	28.6	39	40	38	39	Northwest	Do.
18	22	35	34	30.3	38	39	38	38.3	Southerly	Cloudy.
19	24	40	30	31.3	38	38.5	37.5	38	....do.........	Clear.
20	32	36	27	31.6	37.5	38	37	37.5	Southwest.....	Snow in morning.
21	20	29	27	25.3	35	36.5	36	35.8	Southerly	Clear.
22	32	38	32	34	36	37.5	37	36.8	Variable	Snow.
23	29	34	27	30	35	36	36	35.6	....do.........	Cloudy.
24	29	42	29	33.3	36	36.5	36	36.1	....do.........	Do.
25	36	45	41	40.6	36	37	36	36.3	Southwest	Do.
26	28	37	33	32.6	36	37	37	36.6	....do.........	Do.
27	28	32	33	31	36	36.5	36	36.1	Northwest	Do.
28	26	30	20	25.3	36	37	35	36	....do.........	
29	27	31	35	31	36	36	37	36.3	Northeast.....	Snow.
30	20	25	17	20.6	36	36	35.5	35.9	Southwesterly.	Do.
Means ...	......	......	......	37.3	......	......	......	34.4		
Dec. 1	15	29	27	23.6	36	36.5	35.5	36	Southwesterly.	Clear.
2	30	37	31	32.6	36.5	36.5	36.5	36.5	Variable	Cloudy; rain and snow.
3	34	36	34	34.6	36.5	36.5	36	36.3	Westerly......	Slight snow.
4	31	31	21	27.6	36	36.5	36.5	36.3	Variable	
5	20	35	27	27.3	36	36.5	36	36.2	....do.........	Snow.
6	19	35	23	25.6	36	36.5	36	36.2	....do.........	Clear.
7	10	26	8	14.6	35.5	36.5	35.5	35.8	Westerly......	Do.
8	28	37	33	32.6	35.5	35.5	35.5	35.5	Easterly	Snow and rain.
9	34	33	30	32.3	36	36	35.5	35.8	Northerly.....	Snow.
10	15	18	10	14.3	35	35.5	35.5	35.3	Northwest	Do.
11	10	20	8	12.6	35	35.5	35.5	35.3	Westerly......	Clear.
12	− 9	12	8	3.6	35	36	35.5	35.5	....do.........	Clear in morning, clouds in evening.
13	5	16	6	9	35	36	35.5	35.5	Northerly.....	Clear.
14	21	32	20	24.3	35.5	36.5	35.5	35.8	Southwest.....	
15	32	38	21	30.3	35.5	35.5	35.5	35.5	....do.........	Rain in morning, clear in evening.
16	6	24	23	17.6	35	36	36	35.6	Southeast.....	Snow.
17	20	28	0	16	35.5	36	36	35.8	Northerly.....	Do.
18	− 7	26	27	15.3	35.5	36	36	35.8	Variable	Do.
19	19	23	9	17	36	36	35	35.6	Westerly......	Clear.
20	15	26	17	19.3	35	35.5	35	35.2	Northeast.....	Snow.
21	18	26	− 2	14	35	36	35.5	35.5	Westerly......	Clear.
22	23	16	0	13	35	34.5	34.5	34.6	Northwest	Snow 10 inches.
23	− 8	16	5	4.3	34.5	35	34.5	34.6	Easterly	Snow.
24	− 1	3	−10	−2.6	34.5	34.5	34	34.3	Northwest	Clear.
25	−16	− 1	− 8	−8.3	34	34	34	34	West..........	Do.
26	− 9	2	1	−2	33.5	34	33.5	33.6	Northeast.....	Snow.
27	− 5	9	4	2.6	33	34.5	33	33.5	Northwest	Do.
28	− 5	6	− 3	−0.6	33.5	34	33.5	33.6	Westerly......	Clear.
29	−19	10	5	−1.3	33	34	33	33.3	....do.........	Do.
30	− 3	10	0	2.3	33.5	34	33.5	33.6	Northwest	Do.
31	−10	12	3	1.6	33.5	34.5	34	34	Variable	Snow.
Means ...	......	......	......	14.6	......	......	......	35.17		
1873.										
Jan. 1	−10	22	− 8	1.3	33.5	34.5	33.5	33.8	Northwest	Clear.
2	−12	20	20	9.3	33.5	34	34	33.8	Variable	
3	32	38	33	34.3	34.5	34.5	34.5	34.5	....do.........	Rain.
4	23	36	20	26.3	34	34.5	34.5	34.3	Westerly......	Clear.

TABLE III.—*Record of temperature at hatching-house, &c.*—Continued.

Date.	Temperature of air.				Temperature of water.				Wind.	Weather.
	7 a. m.	1 p. m.	9 p. m.	Mean.	7 a. m.	1 p. m.	9 p. m.	Mean.		
1873.										
Jan. 5	7	28	32	22.3	34	34	34	34	Easterly	Snow and rain.
6	34	30	11	25	33.5	35	36	34.8	Westerly......	Clear.
7	−5	15	−2	2.6	33.5	33.5	33.5	33.5	Northwest....	Do.
8	8	29	31	22.6	34	35	33.5	34.1	Variable	Cloudy.
9	33	31	22	28.6	33.5	33.5	33.5	33.5	....do	Rain.
10	12	22	−2	10.6	33	34	33.5	33.5	Southwest.....	Clear.
11	−11	10	3	0.6	33.5	34	33.5	33.6	Westerly......	Do.
12	−3	7	−1	1	33	33.5	33	33.1	Northwest	Do.
13	−14	20	30	12	33	33.5	33.5	33.3	Southeast	Snow.
14	34	46	15	31.6	33.5	33.5	33	33.3	Variable	Cloudy.
15	1	15	30	15.3	33	33.5	33.5	33.3	Northwest	Clear.
16	33	39	39	37	33.5	33.5	33.5	33.5	Southerly	Cloudy.
17	41	42	32	38.3	33.5	33.5	33	33.3	... do	Rain.
18	20	22	22	21.3	33	33.5	33.5	33.3	Northeast	Sleet.
19	22	34	27	27.6	33.5	34	33.5	33.6	Westerly......	Rain.
20	14	27	28	23	33.5	34	34	33.8	Southerly	Clear.
21	32	36	32	33.3	34	34	34	34	Northwest	Snow.
22	32	34	25	30.3	34	34	34	34	Westerly......	Do.
23	14	15	9	12.6	33.5	34	33.5	33.6	Northwest	Clear.
24	1	9	12	7.3	33	34	33.5	33.5	Northeast.....	Snow.
25	14	22	15	17	33.5	34	33	33.5	Northwest	Clear.
26	2	24	14	13.3	33	33.5	33	33.1	Easterly	Do.
27	28	26	22	25.3	33	33.5	33	33.1	Variable	Cloudy.
28	15	28	23	22	33	33.5	33	33.1	....do	Do.
29	−1	4	−15	−4	33	33.5	33	33.1	Northwest	Clear.
30	−22	19	14	36	33	33.5	33.5	33.3	Variable	Do.
31	18	28	13	19.6	33.5	34	33.5	33.6	Northerly	Do.
Means ...	......	......	......	18.4	......	......	......	34.6		
Feb. 1	19	23	9	17	33.5	34	34	33.8	Northerly	A little snow.
2	−7	7	3	1	33.5	34	33.5	33.7	Northwest	Pleasant.
3	−13	22	21	10	33.5	34	33.5	33.7	Northerly	Do.
4	17	35	32	28	33.5	34	33.5	33.7	Southerly	Foggy.
5	22	25	9	18.7	33.5	34	33.5	33.7	Northerly	Pleasant.
6	−3	32	28	19	33.5	34	34	33.8	Southerly	Do.
7	29	40	34	34.3	34	34.5	34	34.2	South-southe'st	Pleasant in morning, cloudy in evening.
8	24	40	30	31.3	34	34.5	34	34.2	Northeast and westerly.	Snow in morning, pleasant in evening.
9	18	33	9	20	34	34.5	34	34.2	Northerly	Pleasant.
10	0	11	0	3.7	34	34.5	34	34.2	....do	Wind strong; clear.
11	−11	19	13	7	33.5	34	34	33.8	Northeast.....	Snow.
12	12	22	0	11.3	34	34.5	34	34.2	Northerly	Cloudy in morning, clear in evening.
13	−4	17	−2	3.7	34	34.5	34	34.2	Northwest	Clear; wind strong.
14	−1	15	0	4.7	34	34.5	34	34.2	Northerly	Clear.
15	−8	26	−1	5.7	33	34	33.5	33.5	Southerly	Cloudy and pleasant.
16	−6	36	30	20	33.5	33.5	33.5	33.5	Northerly and southerly.	Cloudy; wind variable.
17	29	36	27	30.7	33.5	34	34	33.8	Northerly	Clear.
18	12	27	15	18	34	34.5	33.5	34	Northwest	Do.
19	22	31	32	28.3	34	34.5	34	34.2	Southeast.....	Snow.
20	29	32	10	23.7	34	35	33.5	34.2	Northwest	Clear.
21	−4	27	20	14.3	33	34.5	34	33.8	Northeast.....	Cloudy; wind variable.
22	27	28	17	24	33	34	33.5	33.5	....	Heavy snow.
23	10	27	8	15	33.5	34	33.5	33.7	Westerly and southerly.	Clear.
24	−4	13	6	5.0	33.5	34	33.5	33.7	Southwest	Do.
25	−13	34	24	15	33	34.5	34	33.8	Southerly and westerly.	Do.
26	22	30	26	26	33.5	34.5	33.5	33.8	Northwesterly	Do.
27	6	38	29	24.3	33.5	34	33.5	33.7	Northerly	Cloudy; wind strong.
28	27	40	29	32	33.5	34	33.5	33.7	....do	Cloudy.
Means ...	......	......	......	17.6	......	......	......	33.5		
March 1	27	40	29	32	33.5	34	33.5	33.7	....	Cloudy.
2	26	40	16	27.3	33.5	34.5	33	33.7	Northerly	Clear.
3	24	32	26	27.3	33	33	32.5	32.8	....do	Snow; wind strong.
4	21	26	12	19.7	32.5	34	33	33.2	Northwest	Clear; wind strong.
5	−4	28	9	11	33	34.5	33	33.2	....	Clear, calm.
6	−13	29	25	13.7	33	34.5	33	33.2	Northerly and southerly.	Clear.

TABLE III.—*Record of temperature at hatching-house, &c.*—Continued.

Date.	Temperature of air.				Temperature of water.				Wind.	Remarks.
	7 a. m.	1 p. m.	9 p. m.	Mean.	7 a. m.	1 p. m.	9 p. m.	Mean.		
1873.										
March 7	22	36	28	28. 7	33	34. 5	33	33. 2	Southwesterly	Clear.
8	30	38	36	34. 7	33	35	33	33. 7	Southeast	Do.
9	35	41	20	32	33	34	33	33. 3	Westerly	Snow-squall in morning, clear in evening.
10	23	26	15	21. 3	33	32. 5	32. 5	32. 7	Northeast	Heavy snow.
11	– 4	40	32	22. 7	32. 5	34	32. 5	33	Easterly	In evening snow.
12	30	40	24	31. 3	33	35	33. 5	33. 8	....do	Clear.
13	6	43	26	25	33	35	33. 5	33. 8	Northerly and westerly.	Do.
14	25	41	30	32	33	35	33	33. 7	Northerly	Do.
15	29	42	36	35. 7	33	35	33	33. 7	Southeasterly .	Cloudy, snow in evening.
16	34	43	31	36	33	34	33	33. 3	Southwest	Clear and cloudy.
17	22	40	27	29. 7	33	35	33. 5	33. 8	Northerly	Clear.
18	18	41	30	29. 7	33	35. 5	33. 5	34	Southerly and easterly.	Clear morning, cloudy evening.
19	30	42	26	32. 7	33	35	33. 5	33. 8	Northeast	Cloudy.
20	10	36	30	25. 3	33	35	33	33. 7	....do	Cloudy, snow in evening.
21	32	37	31	33. 3	32. 5	34	33. 5	33. 3	Northeast to southwest.	Heavy snow last night. snow in evening.
22	26	36	29	30. 3	33	35. 5	33. 5	34	Northwest	Clear.
23	25	46	22	31	33	35. 5	33. 5	34	....	Cloudy.
24	16	40	11	22. 3	33	35. 5	33. 5	34	Northwesterly	Clear.
25	4	34	23	20. 3	32. 5	35	33	33. 5	Northerly	Do.
26	–24	39	35	32. 7	33	35. 5	33. 5	34	Northeast	Rain in evening.
27	24	32	25	27	33	35. 5	33. 5	34	Northwest	Snow in morning.
28	6	34	32	20. 7	33	35	33. 5	33. 8	Southeast	Clear.
29	32	44	36	37. 3	33	35	33. 5	33. 8	Southerly and easterly.	Cloudy and rain.
30	36	43	32	37	33	34	33	33. 3	Easterly and northerly.	Rain.
31	30	36	34	33. 3	32. 5	34	32. 5	33	Northeast	Snow.
Means ...	......	......	......	28. 1	......	......	......	33. 9		
April 1	36	48	......	......	32. 5	34	......	......	Northerly	Clear in morning, cloudy in evening.
2	33	32	......	......	32. 5	34	......	......	Easterly	Rain and sleet.
3	34	42	......	......	32. 5	34	......	......	Southerly	Cloudy.
4	37	48	......	......	32. 5	33. 5	......	......	....	
5	32	49	......	......	32. 5	33. 5	......	......	Westerly	Clear.
6	33	42	......	......	32. 5	33. 5	......	......	Easterly	Cloudy and rain.
7	34	40	......	......	32. 5	33	......	......	Southerly	Do.
8	34	37	......	......	32. 5	33	......	......	....do	Rain.
9	34	40	......	......	32. 5	33	......	......	....do	Cloudy and rain.
10	35	43	......	......	32. 5	33	......	......	Southerly and northerly.	Rain in morning, clear in evening.
11	32	46	......	......	32. 5	33	......	......	....	Clear.
12	34	45	......	......	32. 5	33	......	......	Northeast	Partly clear; rain in evening.
13	34	39	......	......	32. 5	33. 5	......	......	....do	Cloudy and rainy.
14	32	38	......	......	32. 5	33. 5	......	......	....do	Snow in morning, then rain.
15	32	45	......	......	32. 5	34	......	......	....do	Rain.
16	35	45	......	......	33	34	......	......	Westerly	Clear.
17	36	48	......	......	33	34	......	......	....	Do.
18	37	49	......	......	33	34	......	......	Easterly	Rain.
19	34	36	......	......	33	33	......	......	Northeast	Snow.
20	41	50	......	......	34	35	......	......	Westerly	Clear.
21	35	38	......	......	33	33. 5	......	......	Northeast	Rain.
22	40	50	......	......	33	34	......	......	West	Clear.
23	36	47. 5	......	......	33	35	......	......	Northwest	Do.
24	43	57	......	......	34. 5	36	......	......	Northeast	Cloudy.
25	44. 5	59	......	......	34. 5	35. 5	......	......	....do	Do.
26	41. 5	49	......	......	36	37	......	......	Northwest	Mostly clear.
27	40	55	......	......	38	39	......	......	Westerly	Clear.
28	42	58	......	......	38	42	......	......	....do	Do.
29	39	60	......	......	38	43	......	......	Southerly	Clear and some cloudy.
30	38	61	......	......	39	43	......	......	....do	Clear.
Means ...	36. 3	46. 5	......	......	33. 7	34. 6	......	......		
May 1	45	65	......	......	41	48	......	......	Northerly	Clear.
2	44	60	......	......	45	49	......	......	Southerly	Cloudy.
3	34	35	......	......	44	44	......	......	Northeast	Snow.
4	39	49	......	......	42	47	......	......	North	Clear.

TABLE III.—*Record of temperature at hataking-house, &c.*—Continued.

Date.	Temperature of air. 7 a. m.	1 p. m.	9 p. m.	Mean.	Temperature of water. 7 a. m.	1 p. m.	9 p. m.	Mean.	Wind.	Remarks.
1873.										
May 5	46	50	......	......	45	47	......	......	Northerly	Showery.
6	42	55	......	......	45	52	......	......	Westerly	Clear.
7	44	58	......	......	47	54	......	......	....do	Do.
8	44	59	......	......	47	55	......	......	Southwest	Do.
9	48	64	......	......	48	54	......	......	....do	Mostly clear.
10	49	51	......	......	51	52	......	......	Southeast	Cloudy; evening rainy.
11	53	55	......	......	51	53	......	......	....do	Cloudy; some rain, in evening thunder.
12	52	60	......	......	50	55	......	......	Southwesterly	Cloudy; showery.
13	45	66	......	......	52	56	......	......	Westerly	Clear.
14	42	55	......	......	51	55	......	......	Northwest	Cloudy; little rainy in morning.
15	42	58	......	......	50	56	......	......	....do	Clear and cloudy.
16	45	60	......	......	52	56	......	......	Northerly	Cloudy.
17	48	52	......	......	52	56	......	......	Northwest	Clear and cloudy; showery.
18	45	60	......	......	53	58	......	......	Westerly	Mostly clear.
19	50	56	......	......	53	57	......	......	Northerly	Clear.
20	48	64	......	......	53	59	......	......	North	Do.
21	43	61	......	......	53	58	......	......	Southwest.....	Do.
22	45	48	......	......	53	54	......	......	Southerly	Rainy.
23	51	71	......	......	54	58	......	......	Southwest.....	Cloudy.
24	52	69	......	......	54	58	......	......	....do	Clear evening; thunder-shower.
25	58	72	......	......	56	64	......	......	Northwest	Clear.
26	56	74	......	......	58	64	......	......	Southerly	Do.
27	57	72	......	......	59	61	......	......	....do	Rain in morning, clear in evening.
28	52	76	......	......	58	64	......	......	Southwest	Mostly clear.
29	69	79	......	......	63	68	......	......	Northerly	Clear.
30	57	59	......	......	64	68	......	......	....do	Do.
31	47	62	......	......	61	66	......	......	Northwest	Do.
Means ...	48. 1	60. 5	......	......	51. 4	56. 3	......	......		

TABLE IV.—*Observations on temperature of Penobscot River, at and near Bucksport.*

[Station 1 is in the entrance of the "Thoroughfare" that separates Bucksport from Orphan Island, and receives, with the flood-tide, a great deal of water from over extensive muddy flats, which warm it up in sunny weather, and on cool nights may have the opposite effect. Being on the east side of the river, the morning sun has less effect than it would on the western shore. Depth, about 30 feet.

Station 2 is in the main channel, opposite Fort Knox, and the tide was so strong that no satisfactory observations of bottom-temperature were secured.

Station 3 is at the southern end of Orphan Island, (town of Verona,) in close proximity to a good salmon-weir in the current, that sets up and down the western or main channel of the Penobscot. Depth, about 30 feet at low water. Observations here made at or a little before low water, each day.]

Date.	Hour.	State of tide.	Time since high water.	Weather.	Temperature of water. Station 1. Bottom.	Station 1. Surface.	Station 2. Surface.	Station 3. Bottom.	Station 3. Surface.
1872.			*Hrs.*						
June 17	3½ p. m.	Low slack	8½	Clear	46	63	......	......	.....
17	5¼ p. m.	Flood	10¼	....do	......	67	......	......	.....
18	5½ p. m.	....do................	9½	Shower	49	61	61	......	.....
18	10 a. m.	Ebb	2	....do	45	55	61	......	.....
18	4 p. m.	Flood	8	....do	45	63	62	......	.....
18	8 p. m.	High slack	12	....do	47	62	54	......	.....
19	a. m.	Low water	......	Clear	......	......	......	45	5
19	5 a. m.	Low slack.............	8½	....do	46	62	61	......	.....
19	8½ a. m.	High slack	12	....do	47	62	......	......	.....

TABLE IV.—*Observations on temperature of Penobscot River, &c.*—Continued.

Date.	Hour.	State of tide.	Time since high water.	Weather.	Temperature of water.				
					Station 1.		Station 2.	Station 3.	
					Bottom.	Surface.	Surface.	Bottom.	Surface.
1872.									
June 19	10 a. m.	Ebb	1	Clear	46	53	56	......	.....
20	a. m.	Low water	......	....do	......	......	......	44	57
20	....	High slack	......	....do	49	64	......	......	.....
21	a. m.	Low water	......	....do	......	......	......	54	58
21	7 p. m.	Flood	8½	....do	50	66	65	......	.....
22	a. m.	Low water	......	....do	......	......	......	57	64
22	8 a. m.	Low slack	8	....do	62	67	67	......	.....
22	1 p. m.	High water	1	....do	51	58	......	......	.....
23	a. m.	Low water	......	....do	......	......	......	46	58
23	9 a. m.	Low slack	8½	....do	63	69	......	......	.....
23	1½ p. m.	Early ebb	½	....do	52	59	......	......	.....
23	p. m.	Low water	......	....do	......	......	......	46	60
24	a. m.	...do	......	Cloudy	......	......	......	47	55
24	1½ p. m.	Early ebb	0	....do	52	59	......	......	.....
25	8½ a. m.	Low water	6	....do	61	66	......	46	57
25	1½ p. m.	High water	12	....do	53	66	......	......	.....
25	8 p. m.	Low water	5½	....do	51	58	......	......	.....
26	10 a. m.	Low water past	6½	Misty and showers	61	68	......	......	.....
27	10 a. m.	Low water	6	Clear	57	64	......	49	61
27	4 p. m.	Early ebb	0	....do	50	60	......	......	.....
28	....	Low water	......	Cloudy	55	63	......	50	60
28	5 p. m.	Early ebb	0	....do	51	59	......	......	.....
29	....	Low water	......	Clear	......	......	......	48	59
29	1 p. m.	Low water past	7	....do	49	65	......	......	.....
29	6 p. m.	Just turned high water	0	....do	50	65	......	......	.....
30	6½ a. m.	Early ebb	0	....do	49	59	......	......	.....
30	....	Low water	......	....do	......	......	......	47	57
July 1	8 a. m.	High water	½	Cloudy	50	60	......	......	.....
1	2 p. m.	Low water	6½	....do	50	65	......	......	.....
2	11 a. m.	High water	2½	....do	48	60	......	......	.....
2	3 p. m.	Low water	6½	....do	49	65	......	......	.....
3	9½ a. m.	High water	½	Hazy	50	61	......	......	.....
3	p. m.	Low slack	......	....do	53	65	......	......	.....
4	11 a. m.	Early ebb	0	....do	50	60	......	......	.....
4	p. m.	Low water	......	Clear, with thunder-shower.	......	......	......	48	57
5	Noon.	Early ebb	1½	Clear	51	62	......	......	.....
5	p. m.	Low water	......	....do	......	......	......	50	58
6	Noon.	Early ebb	2½	....do	52	60	......	......	.....
6	p. m.	Low water	......	....do	......	......	......	46	56
7	7 a. m.	Between low water and low slack.	7½	....do	50	64	......	......	.....
7	p. m.	Low water	......	....do	......	......	......	46	56
8	6 a. m.	....do	6	....do	50	61	......	46	55
8	1 p. m.	Early ebb	0	....do	51	61	......	......	.....
8	7½ p. m.	Low slack	6½	....do	50	65	......	......	.....
9	a. m.	Low water	......	Clear after fog	......	......	......	46	54
9	9½ a. m.	Low slack	8½	....do	50	67	......	......	.....
9	2 p. m.	Early ebb	½	....do	51	62	......	......	.....
10	....	Low water	......	Thunder-shower	......	......	......	45	57
11	....	....do	......	Clear after haze	......	......	......	50	60
12	....	....do	......	Clear	......	......	......	47	57
13	....	....do	......	....do	......	......	......	46	57
14	....	....do	......	....do	......	......	......	47	56
15	....	....do	......	Clear after fog	......	......	......	49	56
Mean during June					51.4	62.3	60.9	48.1	58.3
Mean during July					50.3	62.5	......	47.2	56.6
General mean					51.0	62.4	60.9	47.7	57.6

TABLE V.—*Observations on temperature of water in Eastern River and Dead Brook, Orland, Me.*

[Depth of water in Eastern River, 16 feet; in Dead Brook, 5½ feet. Dead Brook is a long, shallow stream, and the observations were taken at the point where salmon were kept in 1871. Eastern River comes from large ponds, and the temperature was observed within one-half mile of the outlet of one of them.]

Date.	Air.			Water in Eastern River.						Water in Dead Brook.					
				Bottom.			Surface.			Bottom.			Surface.		
	6 a. m.	2 p. m.	Mean.	6 a. m.	2 p. m.	Mean.	6 a. m.	2 p. m.	Mean.	6 a. m.	2 p. m.	Mean.	6 a. m.	2 p. m.	Mean.
1872.															
Aug. 27	......	68	......	......	75.5	......	......	75	......	......	68.5	......	......	......	......
28	52	81	66.5	72	73	72.5	70	74	72	62	71	66.5	61	68	64.5
29	44	76	60	70	74	72	71	73	72	63	63	63	62	68	66
30	56	56	56	70	67	68.5	70	68	69	63	61	62	63	60	66.5
31	51	68	59.5	67	69	68	66	68	67	57	62	59.5	57	62	59.5
Sept. 1	54	69	62.5	67	69	68	67	68	67.5	57	62	59.5	57	62	59.5
2	52	68	60	67	68	67.5	66	69	67.5	60	61	60.5	60	62	61
3	52	62	57	66	66	66	66	66	66	59	62	60.5	59	62	60.5
4	44	61	52.5	64	65	64.5	64	65	64.5	59	61	60	59	61	60
5	43	70	56.5	63	67	65	63	68	65.5	53	63	58	53	63	58
6	46	77	62.5	64	67	65.5	64	68	66	55	64	59.5	56	61	58.5
7	45	70	57.5	63	67	65	63	68	65.5	55	60	57.5	55	60	57.5
Means..	49	68	59.1	66.6	68.9	67.5	66.3	69	67.5	58.4	63.2	66.6	58.3	62.6	66.5

TABLE VI.—*Observations on temperature in Sandy River, at New Sharon, made by J. F. Pratt, M. D.*

[Station 1 is above the dam one-half of a mile; depth of water, 15 feet. Station 2 is below the dam four rods; depth of water, 10 feet.]

Date.	TEMPERATURE OF THE AIR, (FAHR.)		TEMPERATURE OF WATER, (FAHR.)							
			Station No. 1.				Station No. 2.			
			Bottom.		Surface.		Bottom.		Surface.	
	8 a. m.	2 p. m.	7 a. m.	2 p. m.	7 a. m.	2 p. m.	7 a. m.	2 p. m.	7 a. m.	2 p. m.
1872.	64	77	63	62	....	....	62	63	....	....
September 2......	52	66	62	....	62	....	61	62	....	....
3......	49	50	62	....	....	....	61	62	....	....
4......	48	78	61	62	....	65	60	63	61	66
5......	51	73	62	62	62	65	61	64	62	65
6......	65	70	64	65	64	65	63	64	64	64
7......	79	88	65	66	68	70	65	68	66	68
8......	61	70	67	68	68	70	66	68	67	70
9......	52	74	68	69	68	71	67	....	68	70
10......	57	60	67	68	69	67	....	67	68	69
11......	64	74	66	66	68	69	....	68	....	68
12......	65	71	....	66	69	68	66	66	66	68
13......										
Sums	707	851	707	654	596	610	632	715	522	608
Means	58.9	70.9	64.2	65.4	66.2	67.7	63.2	65	65.2	67.5

TABLE VII.—*Observations on temperature of water in the west branch of the Little Androscoggin River, at Norway, Me., made by A. B. Crockett.*

[The place where the observations were made was about one-eighth of a mile from the falls, in water eight to ten feet deep, being the deepest to be found. The bottom temperature was obtained by sinking a can and raising it by a line attached, as in the other cases. This stream drains Pennesseewassee Lake, a body of water of about 200 acres in area, deep and pure, and the place of observation was some distance below the outlet, but before reaching that point the water passed through numerous mill-wheels.]

Date.	TEMPERATURE OF THE AIR, (FAHR.)		TEMPERATURE OF WATER, (FAHR.)			
			Bottom.		Surface.	
	6 a. m.	2 p. m.	6 a. m.	2 p. m.	6 a. m.	2 p. m.
1872.						
August 23	....	....	....	75	....	77
24	....	....	65	77	70	78
25	....	....	71	76	72	78
26	....	....	72	76	72	78
27	....	....	76	76	76	76
28	....	48	70	74	70	74
29	55	55	66	72	66	72
30	51	70	68	68	69	68
31	70	72	61	67	62	65
Sums	76	245	549	661	557	616
Means	25. 3	61. 2	68. 6	73. 4	69. 6	68. 4

TABLE VIII.—*Statement of salmon bought alive at Bucksport in* 1872.

[The weights recorded in this statement were obtained, not by actual measurement, but by judgment at sight, a method which is liable to error, but when passed by an experienced person generally comes very near the true weight. In the third column are given the initials of the persons who furnished the salmon. The number of weirs controlled by each person varied largely, J. A. W. having the salmon from only two, J. W. from four or five times as many. J. A. W.'s salmon were brought only from the northern part of Orphan Island, a distance of less than half a mile; A.'s from three miles down the river; J. W.'s from points still farther down, distant about four miles; still farther, about five miles from Bucksport, around the south end of Orphan Island, were the weirs that furnished A. H. W.'s salmon. The number brought each time generally included the catch of all the tides that had intervened since the last delivery recorded—commonly two tides, sometimes one, sometimes three or more.]

Date.	Hour.	Whence received.	Number of salmon.	Weights of salmon in pounds.	Aggregate weight.	Average weight.	Total for each day.	Average weight for each day.	Price per pound.
1872.					*Lbs.*	*Lbs.*			
June 1	— p. m.	J. A. W.	1	11	11	11	1	11	$0 30
3	— p. m.	J. A. W.	2	10, 11	21	10. 5	2	10. 5	28
6	— p. m.	J. A. W.	7	10, 10, 11, 12, 14, 14, 20¾	91¾	13. 1	7	13. 1	25
7	9. 30 p. m.	A.	8	....	96	12	8	12	25
8	11 a. m.	J. A. W.	1	19	19	19	7	11. 6	25
8	11 a. m.	A. H. W.	3	....	32	10. 6			
8	11 a. m.	J. W.	3	....	30	10			
10	11 a. m.	J. A. W.	5	....	51½	10. 3	23	10. 8	25
10	11 a. m.	J. W.	11	....	116½	10. 6			
10	11 a. m.	A.	6	....	70	11. 7			
10	7. 30 p. m.	J. A. W.	1	....	12	12			
11	7 a. m.	J. A. W.	2	....	24	12	48	12	25
11	11. 30 a. m.	A.	16	....	200	12. 5			
11	1 p. m.	A. H. W.	15	....	173	11. 5			
11	1 p. m.	J. W.	11	....	114	10. 4			
11	8. 30 p. m.	J. A. W.	4	10, 12, 20, 20	62	15. 5			
12	1:30 a. m.	A.	9	....	125	13. 9	29	13. 6	21½
12	1 p. m.	A. H. W.	10	....	117	11. 7			
12	1 p. m.	J. W.	10	....	121	12. 1			
13	10 a. m.	J. A. W.	11	10, 10, 10, 11, 11, 12, 12, 12, 20, 20, 21	149	13. 5	40	11. 9	20
13	— p. m.	A.	7	....	85	12. 1			
13	— p. m.	A. H. W.	8	....	87½	10. 9			
13	— p. m.	J. W.	14	....	156	11. 1			
14	10. 30 a. m.	J. A. W.	4	12, 16, 16, 21	65	16. 2	32	14. 2	20
14	3 p. m.	A. H. W.	7	9, 10, 10, 10, 12, 18, 24	93	13. 3			
14	3 p. m.	J. W.	12	10, 10, 10, 11, 11, 12, 14, 18, 19, 22, 24, 28.	189	15. 4			
14	3 p. m.	J. W.	9	10, 10, 10, 10, 11, 12, 12, 12, 20	107	11. 9			
15	11. 30 a. m.	J. A. W.	5	....	65	13	29	11. 6	20
15	4 p. m.	A. H. W.	12	21, 10, 9, 2, 18, 15, 16, 9, 12, (3=49)	161	13. 4			
15	4 p. m.	J. W.	10	12, 11, 10½, 11, 11½, 9, 12, 11, 11½, 12½.	112	11. 2			
15	4 p. m.	A.	7	20, 11, 10, 9, 9, 9, 7	75	10. 7			

TABLE VIII.—*Statement of salmon bought, &c.*—Continued.

Date.	Hour.	Whence received.	Number of salmon.	Weights of salmon in pounds.	Aggregate weight.	Average weight.	Total for each day.	Average weight for each day.	Price per pound.
1872.					*Lbs.*	*Lbs.*			
June 17	5.30 a. m.	A.	15	20, 18, 17, 16, 12, 12, 12, 12, 12, 11, 11, 10, 10, 9, 9.	191	12.7			
17	6 a. m.	A. H. W.	12	22, 22, 22, 18, 15, 12, 11, 11, 11, (3=32.)	176	14.6	36	13.9	$0 19
17	6 a. m.	J. W.	5	22, 21, 20, 11, 11	85	17			
17	3 p. m.	J. A. W.	4	....	48	12			
18	6 a. m.	A. H. W.	11	17½, 14, 10, 11, 10, 15, 15, 11, 12, 11½, 12.	139	12.6			
18	6 a. m.	J. W.	17	16½, 15, 10½, 11½, 10½, (12=133) ..	197	11.5	38	11.9	19½
18	6 a. m.	A.	8	20, 12, 12, 13, 11, 10, 6, 11	95	11.8			
18	6 a. m.	J. A. W.	2	9, 15	24	12			
19	7 a. m.	A. H. W.	6	9, 10, 10, 10, 11, 12	62	10.3			
19	7 a. m.	J. W.	5	11, 11, 12, 9½, 10½	54	10.8	16	10.8	19
19	7 a. m.	A.	5	9, 9½, 10, 10½, 18	57	11.4			
20	9 a. m.	A.	5	11, 11, 16, 17, 21	76	15.2			
20	9 a. m.	A. H. W.	3	10, 12, 13	35	11.6			
20	9 a. m.	J. W.	7	9, 10, 10, 10½, 11½, 12, 22	85	12.1	19	13.4	19
20	3 p. m.	J. A. W.	4	11, 12, 16, 21	60	15			
21	3 p. m.	A. H. W.	10	(6=67), 9, 10, 10, 11	107	10.7			
21	3 p. m.	J. W.	10	8½, 10, 10, 10½, 10½, 11, 11, 11½, 20, 20.	123	12.3	21	11.7	19
21	3 p. m.	J. A. W.	1	16	16	16			
22	10 a. m.	A.	7	9, 10, 10, 10, 11, 12, 23	85	12.1			
22	10 a. m.	A. H. W.	9	18, 18, 20, 20, 20, (5=49)	125	13.8			
22	10 a. m.	J. W.	20	9½, 10, 10, 10, 10, 10½, 10½, 11, 11, 11, 11, 11½, 11½, 11½, 11½, 14, 20, 21, 22, 23.	261½	13.1	41	13.1	18
22	10 a. m.	J. A. W.	5	....	65	13			
24	10 a. m.	A. H. W.	10	9, 11, 12, 12, 16, 16, 18, 18, 20, 20 ..	152	15.2			
24	10 a. m.	J. W.	16	10, 10, 10, 10, 10½, 10½, 10½, 11, 11, 11, 11, 11, 11½, 11½, 12, 12.	176½	11.3	34	12.4	18
24	10 a. m.	A.	5	9½, 10, 10½, 14, 16	60	12			
24	10 a. m.	J. A. W.	3	....	35	11.6			
25	10 a. m.	J. W.	7	9, 10½, 10½, 11, 11½, 11½, 20	84	12			
25	10 a. m.	A. H. W.	2	11½, 12½	24	12			
25	10 a. m.	A.	7	9, 9, 11, 12, 12, 19, 22	94	13.4	19	12.4	18
25	7 p. m.	J. A. W.	3	10, 12, 13	35	11.6			
26	7 p. m.....	J. W.	13	9½, 10, 10, 10½, 10½, 11, 11, 11, 11, 11½, 11½, 18, 20.	155½	11.9	17	11.5	18
26	7 p. m.....	A. H. W.	4	9, 9, 10, 12	40	10			
27	7 p. m.....	A.	8	8½. 9, 9, 10, 10, 10, 11, 14	81½	10.2			
		J. W.	4	9½, 10, 10½, 12	42	10.5	14	13.3	18
		A. H. W.	2	9, 14	23	11.5			
28	7 p. m.....	J. A. W.	4	....	59	14.7			
28	7 p. m.....	A.	4	9, 10, 11, 22	52	......			
28	7 p. m.....	A. H. W.	8	9, 9½, 10, 11. 12, 16, 18, 20	105½	13.2	25	12.9	19
28	7 p. m.....	J. W.	9	13, 13, 13, 22, 22, 22½, 22½, 23½, 23½.	107	11.8			
29	7 p. m.....	A.	7	8½, 9½, 11, 12, 18, 20, 21	100	143			
29	7 p. m.....	A. H. W.	14	8, 9, 10, 10, 10, 10½, 11, 12, 12, 12, 12, 13, 18, 18.	184½	13.2	29	13.4	20
29	7 p. m.....	J. W.	8	9, 9, 10, 10½, 20, 22, 23, 23	103½	12.9			
July 1	7 p. m.....	A.	9	9, 9, 10, 10, 10, 12, 12, 20, 24	116	12.9			
1	7 p. m.....	A. H. W.	10	10, 10, 11, 11, 12, 12, 12½, 13, 18, 22.	131½	13.1			
1	7 p. m.....	J. W.	15	9, 10, 10, 10½, 10½, 10½, 11, 11½, 11½, 12½, 12½, 13, 20, 20, 22.	194½	12.9	34	13	20
2	7 p. m.....	A. H. W.	6	9½, 10, 10, 11, 12, 12½	65	10.8	11	10.7	21
2	7 p. m.....	J. W.	5	8½, 10½, 10½, 11, 12½	53	10.6			
3	7 p. m.....	A. H. W.	3	10, 10, 11½	31½	10.5			
3	7 p. m.....	J. W.	10	9, 10½, 10½, 11, 11½, 11½, 14, 14½, 14½, 18.	123½	12.3	19	11.4	22
3	7 p. m.....	A.	6	9, 10, 10, 10, 11, 12	62	10.3			
4	7 p. m.....	A. H. W.	10	9, 10, 10, 11, 11, 12, 14, 14½, 15, 17.	123½	12.3			
4	7 p. m. ...	J. W.	10	9½, 9½, 10½, 11, 11, 11, 11½, 14, 15, 19.	122	12.2	25	12.1	22
4		J. A.	5	10, 10, 12, 12, 12	56	11.2			
5	7 p. m.....	A. H. W.	6	9, 10, 10, 10½, 13, 14	66½	11.1			
5	7 p. m.....	J. W.	13	8, 10, 10½, 11, 11, 12, 13, 13, 13½, 14½, 16½, 18, 20.	171	13.1	25	12.1	20
5		A.	6	9, 9½, 10, 10, 10½, 15	64	10.7			
6	7 p. m.....	A. H. W.	5	3¾, 10, 11, 12½, 22	59¼	11.8	11	14.1	18
6	7 p. m.....	J. W.	6	11, 11, 15, 16, 21, 22	96	16			
8	7 p. m.....	A. H. W.	9	10, 10, 10½, 11½, 12, 12, 12½, 13, 16.	107½	11.9			
8	7 p. m.....	J. W.	15	10½, 10½. 11, 11, 11, 11½, 12, 12, 12, 12, 14, 14, 14, 15, 15.	185½	12.3	27	12	19
8	7 p. m.....	A.	3	9, 9½, 13	31½	10.5			

SUMMARY.

Date.	Salmon bought.	Aggregate weight.	Average weight.
	Number.	*Pounds.*	*Pounds.*
June 1 to 15, 1872, inclusive	231	2, 830¼	12. 2
June 15 to 30, 1872, inclusive	309	3, 880½	12. 5
July 1 to 8, 1872, inclusive	152	1, 859¾	12. 2
Total	692	8, 570½	....

General average weight, 12.3 pounds.

TABLE IX.—*Statement of operations in the spawning season of* 1872 *at Bucksport.*

Lot.	Date.	Mother salmon.			Eggs.			Remarks.
		Number.	Length in inches.	Weight, including eggs.	Weight.	Number.	Percentage fecundated.	
	1872.							
1	Oct. 28	1	......	....	....	7, 600	100	
2	Oct. 28	1	......	....	....	8, 700	97½	
3	Oct. 28	1	......	....	....	10, 300	100	
4	Oct. 28	1	......	....	....	12, 400	97½	Female very large; one or both eyes lost.
5	Oct. 28	1	......	....	....	9, 200	97½	
6	Oct. 28	1	......	....	....	7, 600	97½	Heavily milted from one male.
7	Oct. 28	1	......	....	....	7, 600	100	
8	Oct. 28	1	......	....	....	9, 800	100	
9	Oct. 28	1	......	....	....	12, 400	100	Large female.
10	Oct. 28	1	......	....	....	10, 300	100	Do.
11	Oct. 28	1	......	....	....	300	95	Eggs came hard; female supposed unripe, and reserved.
12	Oct. 28	1	......	....	....	700	100	Female small.
13	Oct. 28	1	36	....	....	10, 900	100	Abundantly milted.
14	Oct. 28	1	......	....	....	10, 300	100	Female large and yielded eggs easily.
15	Oct. 28	1	......	....	....	11, 400	87½	
16	Oct. 28	1	31	....	....	7, 600	100	Milt not very plenty.
17	Oct. 28	1	41	....	....	13, 000	100	
18	Oct. 28	1	......	....	....	6, 500	97½	Milted heavily.
19	Oct. 28	1	......	....	....	1, 000	22½	Female appeared unripe, and reserved.
20	Oct. 28	1	......	....	....	6, 500	97½	Turned into troughs while adhering hard together.
21	Oct. 28	....	......	....	....	6, 500	100	
22	Oct. 28	1	......	....	....	8, 200	97½	
23	Oct. 28	1	......	....	....	8, 700	97½	
24	Oct. 28	1	......	....	....	8, 200	95	
25	Oct. 28	1	......	....	....	3, 800	40	Kept in one pan and not stirred.
26	Oct. 28	1	......	....	....	7, 600	100	Stirred 5 minutes; set in three pans.
27	Oct. 28	1	......	....	....	13, 100	100	
28	Oct. 28	1	......	....	....	7, 600	97½	Milt scanty; stood in three pans.
29	Oct. 28	1	......	....	....	7, 600	97½	
30	Oct. 28	1	......	....	....	7, 000	97½	Stirred in one pan.
31	Oct. 28	1	......	....	....	13, 000	100	Stirred in three pans.
32	Oct. 28	1	......	....	....	13, 000	100	Female large; male small; milt scanty; stirred 2½ minutes, then watered heavily, and let stand in three pans.
33	Oct. 28	1	......	....	....	7, 000	100	Stood in one pan.
34	Oct. 29					2, 700	100	Usual way. The two following lot of eggs are from same fish.
35	Oct. 29	1	......	....	....	1, 600	0	Watered first, then stood 2 minutes, then milted by pouring in water and milt from pan containing lot 34.
36	Oct. 29					1, 100	20	Watered first, stood 2 minutes, then milted direct from male.
37	Oct. 29	12	......	....	....	81, 700	99	Usual way.
38	Oct. 28	1	......	....	....	3, 300	95	Female that was thought unripe yesterday. Eggs came hard, with some blood, and some eggs left in fish; milt abundant.

TABLE IX.—*Statement of operations in the spawning season of* 1872, *&c.*—Continued.

Lot.	Date.	Mother salmon.			Eggs.			Remarks.
		Number.	Length in inches.	Weight, including eggs.	Weight.	Number.	Percentage fecundated.	
	1872.							
39	Oct. 29	3	......	....	....	5,900	100	Well milted from two males.
40	Oct. 29	1	......	....	....	4,400	100	
41	Oct. 29	1	......	....	....	7,600	100	
42	Oct. 29	1	......	....	....	300	85	Female was stripped yesterday; eggs of this lot came with much blood; milt fresh.
43	Oct. 30	1	......	....	....	3,300	100	
44						900	100	Milted as usual: handled with care.
45						900	95	Milted as usual, handled carefully till after adhesion, then poured heavily.
46	Oct. 31	1		....	....	900	100	Milted as usual, then poured heavily before adhesion.
47						1,500	100	Watered immediately after milting.
48						1,100	100	Milt taken in water.
49						1,100	7½	Eggs; water; 4 minutes; milt. (Formulas of this sort indicate the exact order of procedure and the time that elapses at each interval; thus in the above instance, the eggs were taken first, then water was added, then, after the lapse of 4 minutes, milt was added.)
50						700	100	Dry method, but milt taken first.
51						700	100	Milt; water; 1 minute; eggs.
52						500	100	Milt; water; 3 minutes; eggs.
53	Oct. 31	1	......	....	....	300	100	Milt; water; 2 minutes; eggs.
54						1,000	100	Milt; water; eggs.
55						400	0	Not milted at all.
56						2,700	100	Usual way.
57	Oct. 31	1	......	....	....	4,400	100	Carried to hatching-house during adhesion.
58						2,000	100	Water; milt; stir a few seconds; eggs.
59	Oct. 31	1	......	....	....	4,100	100	
60	Oct. 31	1	......	....	....	8,200	100	
61	Oct. 31	1	28½	....	....	7,800	97½	
62	Oct. 31	2	28 28	......	....	14,200	100	
63	Oct. 31	1	31	....	....	7,600	100	
64	Oct. 31	2	30 29	......	....	10,900	100	
65	Nov. 1	1	32	....	....	9,800	100	
66	Nov. 1	1	28	....	....	6,500	100	
67	Nov. 1	1	......	....	....	7,600	100	Stood long before milting or watering.
68	Nov. 1	60	......	....	....	16,300	77½	This lot comes from a second stripping of all the females used before.
69	Nov. 1	1	......	....	....	8,700	97½	
70	Nov. 1	1	36¼	....	....	10,900	97½	
71	Nov. 1	1	28½	....	....	4,900	100	
72	Nov. 1	1	31	....	....	8,200	100	
73	Nov. 1	1	27	....	....	3,300	95	
74	Nov. 1	1	28½	....	....	6,500	100	
75	Nov. 1	1	28½	....	....	6,500	92½	
76	Nov. 1	1	30	....	....	6,500	92½	Milt; 10 minutes; eggs; then as usual.
77	Nov. 1	1	30	....	....	6,500	100	
78	Nov. 1	1	30½	....	....	9,300	100	
79	Nov. 1	1	35	....	....	8,700	97½	
80	Nov. 1	1	36	....	....	13,000	100	
81	Nov. 1	1	29½	....	....	9,000	100	
82	Nov. 1	1	30	....	....	6,500	100	
83	Nov. 1	1	29½	....	....	6,500	100	
84	Nov. 1	1	30½	....	....	7,100	100	
85						600	100	Milt taken from fish several hours in advance and kept in open dish.
86	Nov. 1	6	30 31 36 30 31½ 29½	......	....	5,200	100	Five males used.
87	Nov. 1	1	35½	....	....	11,400	100	After standing 1 hour, in two pans, these eggs were still adherent, and were carried to hatching-house in that condition.
88	Nov. 1	4	28 29 34 30	......	....	30,300	100	

TABLE IX.—*Statement of operations in the spawning season of* 1872, *&c.*—Continued.

Lot.	Date.	Mother salmon. Number.	Mother salmon. Length in inches.	Mother salmon. Weight, including eggs.	Eggs. Weight.	Eggs. Number.	Eggs. Percentage fecundated.	Remarks.
	1872.							
89	Nov. 1	1	32	....	....	10,900	100	
90	Nov. 1	10	31 31 29 31 29 29 28 35½ 31 30	....	....	92,600	98	
91	Nov. 1	1	34½	....	....	12,600	100	
92	Nov. 1	1	32	....	....	9,300	100	Stood without milt, while eggs of 93 were taken and milted.
93	Nov. 1	1	30	....	....	8,200	97½	
94	Nov. 2	8	29 31½ 30 30 31 30 30 37	....	....	70,800	100	
95	Nov. 2	1	27	....	....	5,600	100	Eggs came hard.
96	Nov. 2	1	29	....	....	6,500	100	Female caught at Redman's bridge and brought down alive.
97	....	....	....	....	....	200	95	Female had been used before.
98	Nov. 2	1	37	....	....	10,800	100	
99	Nov. 2	1	27	....	....	4,100	97½	
100	Nov. 3	1	30	....	....	500	100	A spent fish that appeared to have just come out of the pond.
101	Nov. 3	1	32½	....	....	8,500	97½	
102	Nov. 3	1	28	....	....	7,600	100	
103	Nov. 3	1	29	....	....	5,400	100	
104	Nov. 3	1	31	....	....	9,200	100	
105	Nov. 3	1	31	....	....	8,800	100	
106	Nov. 3	1	31	....	....	10,000	100	Eggs very small; came hard; female has been kept over; supposed unripe.
107	Nov. 3	1	31½	....	....	9,300	100	Eggs came hard; female was tried before, and supposed unripe.
108	Nov. 3	1	31	....	....	7,600	100	Female in very fine, plump condition; eggs came hard.
109	Nov. 3	1	31	....	....	10,000	100	
110	Nov. 3	1	30	....	....	6,000	97½	
111	Nov. 4	1	29½	....	....	6,700	100	
112	Nov. 4	1	32	....	....	5,000	97½	
113	Nov. 4	1	......	....	....	500	87½	Eggs came with much blood and water.
114	Nov. 4	1	28½	7 12	2 2	5,900	100	
115	Nov. 4	1	29	8 4	2 2	6,800	100	
116	Nov. 4	1	31	12 10	3 2	8,200	100	
117	Nov. 4	1	30	9 6	2 11	7,100	97½	Female caught in pond to-day and lost a few eggs then.
118	Nov. 4	1	37¼	18 11	4 13	13,000	100	
119 120	Nov. 4	1	30¼	9 9	2 9	7,900 500	100 0	Had lost a few eggs. Eggs; water; 2 or 3 minutes; milt.
121	Nov. 4	1	31	8 0	2 11	6,800	100	
122	Nov. 5	1	31	9 5½	2 8¼	7,100	100	
123	Nov. 5	1	27	7 1	1 12	6,100	100	
124	Nov. 5	1	31½	12 8	3 4	9,300	100	Eggs brought down to hatching-house while yet strongly adherent.
125 126	Nov. 5	1	31	....	....	3,300 3,800	100 100	Rinsed immediately after milting. As usual.
127 128	Nov. 5	1	28¾	8 6	2 4	2,700 3,800	100 100	Rinsed immediately. As usual.
129 130 131 132 133 134	Nov. 5	1	30	8 6	2 4	1,100 900 1,100 1,100 1,600 1,600	100 100 100 100 90 80	Milted and watered as usual and carried to hatching-house in ½ hour. Milted but not watered until poured into troughs after standing dry ½ hour. Milt; 5 minutes; eggs carried to hatching-house without water. Milt; 5 minutes; eggs carried to hatching-house with water. Eggs; ½ hour; milt; water; 1 hour; carried to hatching-house. Eggs; ½ hour; milt; 1 hour; carried to hatching-house without water.

TABLE IX.—*Statement of operations in the spawning season of* 1872, *&c.*—Continued.

Lot.	Date.	Mother salmon. Number.	Mother salmon. Length in inches.	Mother salmon. Weight, including eggs.	Eggs. Weight.	Eggs. Number.	Eggs. Percentage fecundated.	Remarks.
	1872.							
135*						1,600	97½	Eggs; milt, &c.
136*						1,600	100	Eggs; water; 1 minute; milt, &c.
137*	Nov. 5	1	31	....	....	1,100	100	Eggs; water; 2 minutes; milt, &c.
138*						1,600	100	Eggs; water; 3 minutes; milt, &c.
139*						1,600	92½	Eggs; water; 4 minutes; milt, &c.
140*						1,600	65	Eggs; water; 6 minutes; milt, &c.
141	Nov. 6	1	29	8 11	2 6	7,600	100	
142	Nov. 6	1	30½	10 1	2 10	7,100	100	
143	....	....	......	....	....	4,400	58½	Female was killed in a rack at hatching-house dam. Eggs taken 2 hours after death.
144	Nov. 9	....	......	....	....	2,700	95	Sundry spent females.
145	Nov. 9	1	......	13 10	2 5	6,400	100	
146	Nov. 9	1	37	18 13	5 2	14,800	97½	
147	Nov. 9	1	......	9 6	4 6	10,400	100	
148	Nov. 9	....	......	....	....	2,700	97½	Sundry spent fish.
149	Nov. 9	1	30½	9 11	2 12	8,100	97½	
150	Nov. 9	1	31	10 13	2 5	7,200	100	
151	Nov. 9	....	......	....	....	1,600	100	Sundry spent females.
152	Nov. 9	1	......	9 14	2 14	8,700	100	
153	Nov. 9	1	38¼	20 8	5 12	13,200	97½	
154	Nov. 9	....	......	....	....	3,800	100	Do.
155	Nov. 9	1	......	10 13	1 13	7,100	87½	
156	Nov. 9	1	31¼	11 14	2 12	8,200	97½	
157	Nov. 9	2	30½	....	2 2	5,400	100	Milt rather scant.
158	Nov. 9	1	35¼	15 12	2 12	6,000	95	
159	Nov. 9	1	35½	17 11	5 6	14,200	100	
160	Nov. 9	1	37	19 13	5 1	9,700	100	
161	Nov. 9	1	37¼	18 5	4 13	13,000	97½	
162	Nov. 9	1	30¾	10 10	2 11	8,500	100	
163	Nov. 9	1	30¼	10 2	2 14	9,300	100	
164	Nov. 9	1	32	13 00	3 9	9,400	100	
165	Nov. 9	1	32½	14 9	3 10	8,700	100	
166	Nov. 9	1	30	9 7	2 3	6,500	67½	
167	Nov. 9	1	31¼	11 4	2 11	7,600	100	
168	Nov. 9	1	29	9 12	2 8	8,700	97½	
169	Nov. 9	1	30¼	8 4	1 3	3,300	100	
170	Nov. 9	1	......	24 2	3 15	8,200	100	
171	Nov. 9	3	......	....	2 7	6,500	100	
172	Nov. 9	2	......	....	....	700	85	Two spent females.
173	Nov. 9	1	31¼	11 7	2 14	8,000	100	
174	Nov. 9	1	36	16 6	3 4	8,200	100	
175	Nov. 9	1	35½	17 13	5 1	12,000	100	
176	Nov. 9	1	36½	18 1	3 15	8,700	100	
177	Nov. 10	15	......	....	....	28,300	97½	Rich's Brook; fifteen living females; three or four of them nearly full, the rest nearly spent; one dead.
178	Nov. 10	2	......	....	....	9,300	67½	Two dead females from Rich's Brook.
179	Nov. 10	1	......	....	....	6,500	2½	Female ripe and good; milt, about a teaspoonful from a dead fish, taken before the eggs.
180						6,500	97½	Usual way, except milt taken from new male that yielded abundantly and kept in dipper until used—say 10 minutes. Same milt fertilized all the rest to 189, inclusive.
181						285	92½	Eggs; water; ¼ minute; milt.
182	Nov. 11	1	37¼	15 3	2 11	220	95	Eggs; water; 1 minute; milt.
183						163	77½	Eggs; water; 2 minutes; milt.
184						151	80	Eggs; water; 3 minutes; milt.
185						175	85	Eggs; water; 4 minutes; milt.
186						202	87½	Eggs; water; 5 minutes; milt.
187						170	85	Eggs; water; 6 minutes; milt.
188						435	0	Eggs; water; 8 minutes; milt.
189						413	2½	Eggs; water; 10 minutes; milt.
190	Nov. 11	1	36½	16 10	4 10	11,400	95	Usual way; was poured into pail a little harder than usual; poured from four to five inches.
191	Nov. 11	1	33	11 9	1 9	4,000	95	
192	Nov. 11							

* In these lots, which were taken at the same time, the milt was first taken in a dish dry. Eggs then taken, divided, and watered. Then, after the lapse of time specified in each case, the milt poured in and eggs stirred. All then stand till free.

TABLE IX.—*Statement of operations in the spawning season of* 1872, *&c.*—Continued.

Lot.	Date.	Mother salmon. Number.	Mother salmon. Length in inches.	Mother salmon. Weight, including eggs.	Eggs. Weight.	Eggs. Number.	Eggs. Percentage fecundated.	Remarks.
	1872.							
193	Nov. 1	13	......	....	....	48,900	100	Collected at Rich's and Lake's Brooks.
194	Nov. 11	4	......	....	....	2,200	0	Taken from specimens killed on 9th inst.
195	Nov. 11							
196	Nov. 11	1	......	....	....	2,400	52½	Brought from Rich's Brook.
197 to 207	Nov. 13 to Nov. 13	1	......	....	....	4,000	97½	
208	Nov. 13	2	......	....	....	1,100	35	From two dead females.
209	Nov. 13	....	......	....	....	13,000	100	From Rich's Brook.
210	Nov. 14	1	......	....	....	4,400	100	
211	Nov. 14	1	......	....	....	3,500	100	Usual way.
212 to 221	Nov. 14 to Nov. 14	1	......	....	....	2,700	......	Experiments.
222	Nov. 14	3	......	....	....	300	92½	From three spent fish.
223	Nov. 14	1	......	....	....	200	0	Not milted.
224	Nov. 14	1	......	....	....	9,500	90	
225	Nov. 14	....	......	....	....	200	90	Eggs kept in a pan without water 12 hours before milting.
226	Nov. 14	....	......	....	....	200	0	
227	Nov. 15	....	......	....	....	400	0	From a fish that has been dead 15 hours.
228	Nov. 15	....	......	....	....	100	0	Eggs kept in a pan without water 30 hours before milting; milt from male that has been dead two days.
229	Nov. 15	....	......	....	....	200	87½	Eggs kept in a pan without water 30 hours before milting; milt fresh.
230	Nov. 15	....	......	....	....	500	92½	Eggs from dead fish.
231	Nov. 15	1	......	....	....	10,500	95	From Rich's Brook.
232	Nov. 15	....	......	....	....	250	91	Picked from bottom of Rich's Brook.
233	Nov. 16	....	......	....	....	200	......	Picked up from brook near hatching-house.
234	Nov. 16	....	......	....	....	300	75	Eggs kept two days without water, and then milted with fresh milt.
235	Nov. 16	1	....	....	....	7,000	100	Usual way.
236 to 245	Nov. 16 to Nov. 16		....	....	....	1,000	......	Experiments.
246	Nov. 16	....	......	....	....	700	90	From Rich's Brook.
247	Nov. 16	....	......	....	....	1,000	0	Do.
248	Nov. 18	....	......	....	....	80	0	Eggs kept four days without water, then milted with milt from dead fish.
249	Nov. 18	....	......	....	....	50	0	Eggs kept four days without water, then milted with milt kept four days.
250	Nov. 18	....	......	....	....	100	12½	Eggs kept four days without water, then milted with new milt.
251	Nov. 18	....	......	....	....	300	30	Eggs from dead fish.
252	Nov. 19	....	......	....	....	100	52½	
253	Nov. 19	....	......	....	....	150	12½	Eggs taken from dead fish yesterday; milt new.
254	Nov. 19	....	......	....	....	200	0	Not milted.
255	Nov. 21	....	......	....	....	200	0	
256	Nov. 21	1	......	....	....	3,300	72½	Eggs came with more water than usual.
257	Nov. 21	....	......	....	....	500	0	Not milted.
						1,560,044		

TABLE X.—*Experiments in transportation of salmon-eggs, from Bucksport, Me., to Winchester, Mass.*

[These eggs were sent in small lots, by express, and received the common treatment of article transported in that way, the battered condition of the boxes often attesting the rough way in which they had been handled. All except the last lot were packed on disks of mosquito-netting, sewed on to brass rings, in alternate layers, with wet bog-moss, in tin boxes, and the latter were inclosed in larger tins, the space between, ½ inch to 1 inch, being filled with sawdust. In some cases, coarse paper was wrapped in several layers around the whole parcel. The packages left Bucksport on the steamer Katahdin, and generally reached their destination the following day. Being exposed to a severe temperature on several occasions, while in the delivery-wagon at Winchester, some of the parcels were penetrated by frost.]

Mark.	Number of eggs.	Date.	Age since fecundation.	Lot.	State of development.	Died on way.		Remarks.
						Number.	Percentage.	
		1872.						
216	50	Dec. 5	38 days..	1	....	9	18	Package frozen badly.
217	50	Dec. 5	34 days..	80	....	16	32	
218	50	Dec. 5	30 days..	125	....	36	72	
219	50	Dec. 5	26 days..	175	....	49	98	
220	50	Dec. 5	21 days..	210	....	45	90	
221	50	Dec. 9	42 days..	1	....	35	70	Frozen so that the moss was all stiff.
222	50	Dec. 9	38 days..	80	Embryo covers yolk	3	6	
223	50	Dec. 9	34 days..	125	......do	17	34	
224	50	Dec. 9	30 days..	175	Embryo covers ⅘ of yolk.	35	70	
225	50	Dec. 9	25 days..	210	Embryo not expanded...	38	76	
226	50	Dec. 17	50 days..	1	Heart beating...........	0	0	Package inclosed in paper, which protected against cold, and against the jar of rough handling.
227	50	Dec. 17	46 days..	80	Embryo covers yolk	0	0	
228	50	Dec. 17	42 days..	125	......do	1	2	
229	50	Dec. 17	38 days..	175	Embryo covers 4-5 of yolk	21	42	
230	50	Dec. 17	33 days..	210	Embryo covers ⅗ of yolk.	1	2	
231	50	Dec. 24	57 days..	1	....	0	0	Some frost in the box.
232	50	Dec. 24	53 days..	80	....	0	0	
233	50	Dec. 24	49 days..	125	....	0	0	
234	50	Dec. 24	45 days..	175	Embryo covers yolk	18	36	
235	50	Dec. 24	40 days..	210	......do	4	8	
1	100	Nov. 14	17 days..	1	Embryo expanding	100	100	
80	100	Nov. 14	13 days..	80	Embryo beginning to expand.	100	100	
125	100	Nov. 14	9 days..	125	....	97	97	Nearly all died afterwards.
196	100	Nov. 14	2 days..	196	....	96	96	
210	100	Nov. 14	½ hour..	210	....	41	41	
401	100	Nov. 20	23 days..	1	Embryo covers 4-5 of yolk	62	62	
402	100	Nov. 20	19 days..	80	Embryo covers ¼ of yolk	45	45	
403	100	Nov. 20	15 days..	125	Embryo just beginning to expand.	36	36	
404	100	Nov. 20	11 days..	175	....	21	21	
405	100	Nov. 20	6 days..	210	....	0	0	
406	50	Nov. 21	24 days..	1	....	10	20	
407	50	Nov. 21	20 days..	80	....	4	8	
408	50	Nov. 21	16 days..	125	....	4	8	
409	50	Nov. 21	12 days..	175	....	1	2	
410	50	Nov. 21	7 days..	210	....	4	8	
411	50	Nov. 25	28 days..	1	Embryo covers whole yolk.	44	88	
412	50	Nov. 25	24 days..	80	Embryo covers ¼ yolk...	42	84	
413	50	Nov. 25	20 days..	126	Embryo slightly expanded.	5	10	
414	50	Nov. 25	16 days..	175	....	4	8	
415	50	Nov. 25	11 days..	210	....	0	0	
		1873.						
236	1,500	Jan. 7	71 days..	1	Eyes black...............	12	¾	Packed with moss on wire trays, and inclosed in sawdust.
237	1,500	Jan. 7	71 days..	1	......do	31	2	
238	500	Jan. 7	67 days..	80	....	5	1	
239	500	Jan. 7	63 days..	125	....	23	4½	
240	500	Jan. 7	59 days..	175	....	211	42	
241	50	Jan. 7	71 days..	1	....	0	0	Packed in tins as usual, inclosed in sawdust and paper.
242	50	Jan. 7	67 days..	80	....	2	4	
243	50	Jan. 7	63 days..	125	....	0	0	
244	50	Jan. 7	59 days..	*175	....	35	70	
245	50	Jan. 7	54 days..	210	....	5	10	

* The excessive mortality in the eggs belonging to lot 175 I attribute in part to their being in an unhealthy state.

TABLE XI.—*Statement of the distribution and hatching of the salmon-eggs collected at Bucksport in the season of 1872, and of the distribution of the young fish.*

Party receiving.	Number of eggs received.			Loss.		No. of young salmon distributed.	In what waters distributed.
	Own account.	Allotted by United States.	Total.	Percentage.	Amount.		
Maine	74, 000	228, 000	302, 000	31	95, 000	207, 000	Penobscot River and tributaries, 67,000; Saint Croix River, 10,000; Androscoggin and tributaries, 130,000.
New Hampshire	....	21, 400	21, 400	35	7, 400	14, 000	Merrimac and tributaries.
Vermont	....	10, 000	10, 000	30	3, 000	7, 000	Winooski and Lamoille Rivers.
Massachusetts	202, 000	30, 000	232, 000	19	45, 000	187, 000	Merrimac River, 165,000; Mystic River, 11,000; Red Brook, 11,000.
Rhode Island	90, 000	10, 000	100, 000	36	36. 000	64, 000	Blackstone, Pawtucket, and Pawcatuck Rivers.
Connecticut	184, 000	80, 000	264, 000	25	66, 000	198, 000	Saugatuck River, 4,500; Southport River, 4,500; tributaries of the Connecticut River, 115,000; Mystic River, 5,000; tributaries of Thames River, 10,000; Housatonic River, 70,000; stream at North Branford, 35,000.*
William Clift	64, 000	....	64, 000	33	21, 000	43, 000	
New York	....	80, 000	80, 000	32½	26, 000	54, 000	Peat Wig Creek and Inglesby Creek, tributaries of the Hudson, 24,000; Beaver Creek, tributary to Salmon River, Oswego County, 15,000; Glass House Creek, Cayuga County, tributary to Oswego River, 15,000.
New Jersey	....	40, 000	40, 000	10	4, 000	36, 000	Tributary of Delaware River, 18,000; tributary of Raritan River, 18,000; Long Island, 3,000.*
Pennsylvania	....	40, 000	40, 000	37½	15, 000	25, 000	Delaware River.
Ohio	....	5, 200	5, 200	52	2, 700	2, 500	Cold Creek, tributary to Sandusky Bay.
Michigan	....	43, 200	43, 200	55	23, 700	19, 500	Kalamazoo, Saint Joseph, Grand, Muskegon, Manistee, Au Sable Rivers, about equal numbers; Orchard, Walled, Whittemore, Diamond, and a few smaller lakes.
Wisconsin	....	40, 000	40, 000	52½	21, 000	19, 000	Menomonee River, 7,000; Oconomowoc Lake, 1,000; Milwaukee River, 11,000.
Totals	614, 000	627, 800	1, 241, 800	29. 4	365, 800	876, 000	

* The sums of the fish reported distributed in the several streams in Connecticut and New Jersey exceed the computed number in the preceding column; the discrepancy may have arisen from an error in counting out the young fish, which cannot be done accurately without a deal of labor.

D—LOCAL HISTORY OF SALMON AND SALMON-FISHING IN NEW ENGLAND RIVERS.

1.—GENERAL OBSERVATIONS.

The sea-going salmon of eastern North America, *Salmo salar*, Linn., is native to nearly every river tributary to the Atlantic north of the Hudson. If we apply the term "river" only to streams of fresh water of sufficient size to afford full-grown salmon ample room to move and lie in during the summer drought, we shall find that the only exceptions to the former universal prevalence of the species within the district named are those rivers that do not contain suitable breeding-grounds, or whose breeding-grounds are inaccessible to salmon by reason of the intervention of impassable falls between them and the sea.

In all rivers frequented by them they are found successively in all parts from the mouths upward, their migrations extending nearly to the head-waters both of the main rivers and their tributaries, always with the same limitations mentioned above as to the presence of breeding-grounds and their accessibility. To this statement, however, there appears to be one important exception in the case of the Saint Lawrence. Such evidence as I have been able to gather relating to the migration of salmon in this river tends to the conclusion that few, if any, ascend it so far as Lake Ontario, and that the salmon inhabiting that lake and its tributaries make the lake their sea and the limit of their downward migrations.* Though extensive salmon-fisheries are carried on on both sides of the Saint Lawrence below Quebec, the capture of a salmon in that part of the river above Montreal appears to be a rare event. In the lower tributaries of that river the migrations of salmon are precisely similar to those observed in rivers emptying directly into the sea, and extend to all accessible upper waters where suitable places for the deposit of their eggs are to be found.

The researches of which the results are embodied in the following notes did not extend to any rivers beyond the limits of the United States. It will be seen that nearly every river, from the eastern border to the Housatonic, is known to have been formerly frequented by salmon, and it is not unlikely that the list would be increased by the addition of quite a number of minor streams were the history of the latter known. Of the twenty-eight salmon rivers mentioned below, lying wholly or in part in the United States, there are barely eight where salmon are now regular visitors. These are the Saint Johns, Saint Croix, Denny's, Little Falls, (a small stream in Edmunds, Me.,) East Machias, Wescongus, Penobscot, and Kennebec. They are sufficiently numerous to support a regular fishery in the

* There is also some doubt about the migration of the salmon formerly inhabiting Lake Champlain and its tributaries. Further research is required on both these points.

Saint John's, and its larger tributary, the Aroostook, Saint Croix, Denny's, Penobscot, and Kennebec. Beside the rivers regularly visited by them, they are occasionally observed in the Machias, Narraguagus, Sheepscot, Androscoggin, Presumpscot, and Saco; but in all these, as well as the remaining fifteen rivers, the ancient brood of salmon was long ago extinguished, and the rare specimens occasionally observed must be regarded either as strays from some of the better-preserved rivers, or as early-returning members of the new broods established by artificial culture in several rivers. The latter appears to be the most probable explanation of the recent occurrence of salmon in Southern New England.

The disappearance of salmon from so many rivers appears to have been entirely the result of artificial causes, chief among which is the obstruction of the way to their breeding-grounds by impassable dams. Excessive and ill-timed fishing has had a due share of influence in depleting the original supply and in preventing its speedy recovery in cases where other circumstances were favorable, but, unaided by the formidable works of the manufacturer, the fisherman's nets and spears and pounds would hardly have sufficed to extinguish the brood of salmon in a single river. Commonly these two classes of destructive agencies co-operated. The dams held the fish in check while the fisherman caught them out. This has been the case for many years, and is the case to-day with the Saint Croix, Denny's, Penobscot, and several others, where, though impeding the ascent of salmon, the dams have not wholly prevented it. There are, however, other rivers, where the dams alone would have sufficed to exterminate the species. As instances may be mentioned the Androscoggin, Saco, and Merrimac, where the dams so completely exclude salmon from all suitable spawning-grounds that, without the intervention of any other agency, they would have extinguished the broods that naturally frequented those rivers.

2.—TRIBUTARIES OF THE SAINT JOHN RIVER.

Salmon ascend the Saint John as far as Grand Falls, where they find an impassable obstacle to their further progress. Nearly all the tributaries below this point, on both sides, were originally frequented by them, and in these their spawning-grounds are supposed to have been mainly situated. The complete closing of some of these tributaries by dams, and the partial closing of others, has tended to the decrease of the species. But large numbers are still found in the main river and such of the tributaries as are accessible. Of the tributaries lying partly in the State of Maine, the Aroostook, Presque Isle, and Meduxnekeag were naturally frequented by salmon. With regard to the Aroostook and Meduxnekeag, there is no doubt of their having ascended both streams beyond the border-line. Such was probably the case with the Presque Isle River, as is assumed by Mr. Venning, inspector of

fisheries for New Brunswick and Nova Scotia,* although I have not succeeded in obtaining direct testimony to the fact.

Aroostook River.—The ascent of salmon is seriously impeded by a natural fall, known as "Aroostook Falls," about four miles above the junction of the river with the Saint John, and just within the borders of New Brunswick. So great is the difficulty of ascent that in Perley's report on the fisheries of New Brunswick in 1851 it was stated that no salmon ever passed it. It appears that he was by no means correct, although it may readily be believed that a small proportion of the salmon that come to this fall succeed in surmounting it. The banks of the river here approach each other and form a narrow gorge; down this the water rushes swiftly for three-quarters of a mile, and at last makes a perpendicular plunge of fifteen feet, into a broad smooth basin on a level with the Saint John. In this basin the salmon naturally accumulate while hesitating to attempt the fall, and many are there speared by torchlight. Near the most difficult part of the fall is a little pool of still water into which salmon frequently drop exhausted, and stay a short time to rest. At favorable stages of the water it is said that more salmon are caught in this little pool than in all the rest of the river.†

Above Aroostook Falls, the river is smooth and gentle for many miles, and the facilities for taking salmon are consequently poor. A few are, however, caught with nets and spears all along. The number of nets is very small, nearly all the fishing being done with spears. There are no artificial obstructions on the main river, and salmon can run quite to its headwaters. They have been caught a hundred miles above its mouth. Their favorite stream in old times was the Big Machias. A dam built near its mouth about thirty years ago shut the salmon out almost completely, but occasionally one leaps the dam. From the tributaries below this point they are likewise shut out by dams. In Presque Isle Stream and Salmon Brook they were formerly abundant.

The data at my command do not furnish a sufficient basis for an estimate of the number of salmon caught on the Aroostook. One correspondent estimates that in 1873, which was the best year for a long time, 125 were caught within two miles of Caribou. Another says that in the vicinity of Salmon Brook and Machias 200 were speared the same season; and that one net just above Fort Fairfield took eleven in one night. Three years ago the fishing is thought to have been at its lowest ebb.

The average weight of the salmon caught in the Aroostook is estimated by one correspondent to be ten pounds; by another twelve pounds. Grilse are occasionally seen, but not often. They are caught in August. The first run of adult salmon reaches Caribou and Castle Hill about the first of July; their appearance at Aroostook falls is said to be from

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* Annual Rept. (Canadian) Dept. Marine and Fisheries for 1869, p. 79.

† Letter of F. M. Everleth.

the middle of June to the first of July. The main run reaches Caribou about July 20, and the last run the last of August.

Meduxnekeag River.—In 1816 salmon were very plenty on this river in the vicinity of Houlton. They continued so until 1826, when they were shut out by dams that were built across the stream at different points. Since that time few have been caught above Woodstock, where the first obstruction is encountered. Alewives also formerly frequented this river, and have shared the fate of the salmon. A fish-way was built over the dam at Woodstock in 1868, and both salmon and alewives are reported to have passed through it the following year.*

3.—SAINT CROIX RIVER.

This river once yielded large numbers of salmon. The principal fishery previous to 1825 was that carried on at Salmon Falls in Calais, a short distance above tide-water. The whole river is here compressed into a narrow and steep passage, which, although difficult, was in its natural state surmounted by great numbers of salmon, shad, and alewives. There were several side-channels into which the fish crowded in order to avoid the furious current of the main channel, and here they were easily taken with dip-nets. The following statements, reported by Perley, illustrate the abundance of salmon. A boy of fifteen has been known to take 500 salmon at these falls with a dip-net in a single year, and a man has taken 90 to 100 salmon two days in succession in the same mode. Another man, standing on a jam of logs a short distance below the falls, took 118 salmon in one day. Such occurrences do not appear to have been common, and afford no basis from which to compute the total yield.

Above Salmon Falls there has been very little salmon-fishing done at any time. The extent of the range of salmon on the upper waters at that time cannot be now ascertained. I have it from an intelligent Indian of the Passamaquoddy tribe, Piel Toma, who lives near Princeton, that fifty years ago they were caught at Grand Lake stream on the west branch. The Indians call the sea-salmon *Pl-láhm*, in distinction from the *land-locked* salmon, which they call *Tag-e-wah-nahn.*

Dams were built on this river probably a century ago, but previous to 1825 they were all provided with ways for the passage of migratory fish, of such a character that the dams did little or no harm to the fisheries. But in 1825 the Union dam in Calais was built, and remained for many years without an adequate fish-way. Being situated in tide-water, it completely shut out from their breeding-grounds all the migratory fishes, except such as could surmount it at high water, in exceptionally high tides. That this was occasionally possible with salmon there is no doubt. But so long were the fish kept in waiting for a favorable oppor-

* Letters of T. P. Packard, J. R. Weed, Bernice Royal.

* Annual Rept. (Canadian) Dept. Marine and Fisheries, for 1870, p. 289.

tunity to ascend, that they were too much exposed to be taken by the spears and nets that were constantly plied both within and without the lawful limit, and they rapidly diminished in numbers. In 1850 it was estimated by Mr. Perley's informants that the number of salmon caught on the whole river did not exceed 200 yearly. From that time for fifteen years the catch remained very small; some seasons it was estimated to have been only about 100. In 1866 and 1867 there was a marked increase, and at the present time the salmon appear to be gaining in numbers.

In 1869 fish-ways were built over the dams at Union Mills and Baring, which were the only ones on the lower part of the river that were without suitable provision for the passage of fish. The dams at Milltown were built out from either shore obliquely up stream, and, at the point of meeting, a gap several feet wide answered the purpose of a fish-way admirably except when choked with logs, a contingency not seldom occurring. The fish-way at Union Mills was built after a design by the late N. W. Foster, who was chairman of the State board of commissioners of fisheries in 1867 and 1868. Alewives were seen passing up through this fish-way in great number the first season it was opened, and salmon are supposed to have accompanied them, quite a number being seen above that point. The dam at Baring was passable not only by means of the legal fish-way, but also by a broad stream of water that was allowed to run around one end during all the early part of the fish season. In 1873 salmon were seen at Vanceborough on the east branch, and one was hooked there by Mr. Commissioner Stanley. The dam at Vanceborough and also that at Forest City, twenty miles above on the same branch, were also provided with fish-ways in 1869; and the only dam on the river now without a fish-way is that at Princeton, on the west branch.

The aboriginal mode of catching salmon was with the spear, and this implement was still in use near the lower dam in 1850. The whites use dip-nets on the falls, drift-nets on the rapids wherever the bottom is smooth enough, and weirs in the tidal parts of the river. The dip-net has not been much used since salmon became scarce, but until very recently dip-nets have been used with fatal effect just below the Union Dam, in Calais. Weirs are built at several points in tide-water. Since 1860, they have increased in number. At the present time there are built six or seven of all kinds. Mr. Lewis Wilson, who has built a weir on the American side of the river since 1850, has given me much valuable information. From one of his letters I extract the following:

"The yield of salmon, judging from the production of our weir and what I hear, is very irregular, five times as many some years as in others. I estimate the range in different years from 100 to 500, averaging perhaps 300 or 350 annually. I think they are rather on the increase, comparing our catches latterly with those fifteen or twenty years ago. Though we take only about the same number that we formerly did, or a slight

increase, then there was no weir to interfere with ours. For the last ten years or so, there has been a weir a mile or two below ours, which probably diminishes our catch from what it otherwise would be. Last season there were below the 'ledge' three weirs of the kind which retain the fish at high water, and three or four half-tide weirs above the ledge, two of which, of each kind, were on the American side. For several years previous there were none on the eastern side. And from about 1850 to to 1860 our weir was the only one of the kind on the river. Prior to that for a number of years there were none.

"The principal fish caught in them, more particularly in ours, naming them in the order in which they first come, though the different kinds run into each other, are herring, codfish, alewives, salmon, sea-shad, (but very few river-shad,) a kind of sea-alewife called blue-back, and formerly small mackerel, but of late they seem to have forsaken the river. Many other kinds in smaller quantities, but all help to make fares. Salmon and alewives pay the best. The latter has increased a hundred fold, I think, in the last ten years.

"The salmon run larger some years than in others, perhaps an average of two pounds in weight. Last season they ran large. With regard to grilse my information is confined to our weir; we occasionally catch what we call young salmon, perhaps three or four a year, weighing about three to five pounds. We also catch another kind, about the same number, which were called grilse by those who fished here before us, but which I think is a species of trout, unlike the young salmon, weighing perhaps from one to two and one-half pounds; large head, lean body, dark color, and very inferior to young salmon for food; some of these have spawn. Twelve or fifteen years ago, more or less, Mr. Upham Treat, of Eastport, put several salmon, perhaps ten, from our weir into Shattuck's Lake, in the lower part of this town, the outlet of which is in the upper part of Robbinston. One season several years afterward, (I cannot recall dates,) we caught more salmon than in any season before or since—more than our usual proportion, compared with those caught at the head of the tide, as far as we learned, and of an unusual uniformity in size. Our theory at the time was that they were the offspring of Treat's salmon; that the stream being too small for them to enter, and they not being inclined to go up the river, they dallied about in that vicinity and got entrapped."

The weir built by Mr. Wilson consists of a "hedge" and two inclosures, the "big" and "little" pounds. The hedge runs from the shore out to the entrance of the big pound, and is made of stakes, brush, and net. The big pound is about sixty-two feet long and thirty feet wide, and its entrance is sixteen feet wide. It is of the same material as the hedge. From the big pound the fish pass through a passage-way, nine inches wide at the bottom and fourteen at the top, into the little pound. The little pound is circular in shape, about fourteen feet in diameter; has a board floor raised several feet above the ground and walls of net-

ting. The pounds are near low-water mark, and at high water of ordinary tides the floor of the little pound is sixteen feet under the surface. The distinguishing feature of this weir, when compared with those built on the Penobscot, is the position of the second pound, which is on the lower or down-river side of the first pound; on the Penobscot it is always on the upper side.

Mr. Wilson has furnished a statement of the catch of salmon in his weir for the last ten years, together with some explanatory remarks which are herewith submitted:

"With regard to the number of salmon caught here last summer and how it compares with other years, owing to the operation of the fish-law, there seems to be no basis for an intelligent estimate. The prohibition covers nearly all the fishing-ground at the head of the tide where most of the salmon used to be caught, and but comparatively few are caught there now unless by stealth. I can inform you how our number compares with other years, but how much, if any, this number is increased by salmon falling back, that would have been caught at the head of the tide were there no restriction more than heretofore, I have no grounds for even a guess. That some drop down is quite certain, for we have caught several showing unmistakable marks about the gills of having been meshed, when nets were used only at or near the head of the tide.

"During the last ten years our 'catches' have been as follows, the place and plan of the weir the same every year:

Year.	No. of salmon.	Year.	No. of salmon.
1864	30	1869	22
1865	27	1870	35
1866	109	1871	117
1867	104	1872	55
1868	93	1873	84

"In 1871 and 1872 we observed the two weekly close-days to July 15. The other two weirs, one on each side of the river, two to three miles below ours, have caught each, I estimate, nearly as many as we have. The several half tide weirs may have caught not to exceed a half dozen. I can make no estimate of the number caught at Union Mills, the head of the tide. If I could it would be no test, as there would be no clew to the number diminished by the protective law.

"The average weight of the salmon we caught in 1870 and 1871 would not exceed 10 pounds each, about 9½ pounds according to our accounts; in 1872 and 1873 about 12½ pounds."

4.—DENNY'S RIVER.

Salmon abounded in this river in its primitive state. The Cathance, the principal tributary, was more frequented by them than was the main river above the mouth of the former. But the Cathance has been utterly closed up by dams, and for some years subsequent to

1840 an impassable dam was maintained on the main river about a mile above the head of the tide. As a natural result the salmon became comparatively scarce. A sufficient breeding-ground, however, remained open to them to prevent their utter extermination, and they have continued to frequent the river in fluctuating numbers until the present time. In 1858 the impassable dam on the main river fell into disuse, and for a dozen years presented no obstacle to the ascent of fish. Since the river was thus re-opened, the principal hinderance to the increase of salmon has been the unreasonable persecution that they have received at the hands of a lawless class of citizens. So unrelenting has been the pursuit, with set-nets, dip-nets, spears, stones, and clubs, that, in spite of the improved facilities for ascending the river, there has been no marked increase.

Salmon in the earlier stages of growth have been observed in the Denny's much oftener than in rivers farther west. One observer who has been familiar with the river and its fisheries for many years, says that in his boyhood, when salmon were plenty, he and his comrades used to catch both salmon-smolts,* from five to seven inches long, and parr, in great numbers. One or both of these are also now caught at Dennysville by anglers, but in less numbers than formerly. Grilse are sometimes taken in this river, but are not abundant. Mr. Lincoln says that among thousands of salmon caught there that came under his own observation, there were only five or six grilse. Even at this rate, however, they appear to be more plenty than in the Penobscot. The average size of the adult salmon in 1873 Mr. Lincoln estimates to be about ten pounds of the preceding year.

The total yield of Denny's River for 1873 is estimated to have been one thousand salmon. It was somewhat larger than in 1872. They were caught, as they have been for many years, in set-nets, at the narrows, in tidal water, a short distance below Dennysville village, and with dip-nets and spears in the vicinity of the dams. The number of set-nets employed is ordinarily ten or twelve. They are simple straight nets, forty feet long and about six feet deep, and take salmon by meshing them. When set they run from the shore obliquely down stream, making an angle of about forty-five degrees with the shore, the upper edge of an eddy being a favorite place. They are fastened to the bottom, and being only six feet high the tide covers them completely in two or three hours after it begins to flow. The salmon are supposed to ascend without any hinderance from the nets during flood tide, but on the ebb they are thought to drop back into the eddies and get caught in the nets.

* Letter of Benjamin Lincoln. Mr. L. says: "We used to catch great numbers of what we boys then called young salmon, little fellows from five to seven inches long, with little silvery scales like a miniature salmon, and also a little fellow with red spots and bars, like a trout, only lighter colored; these we also called young salmon. But as the salmon have decreased with us I notice that the boys catch less of these."

This is the only river in New England, except the Narraguagus, where fly-fishing for salmon has ever been practiced. In 1867, and for several years before and after that date, several gentlemen from Portland and Boston fished it for some weeks each season, and met with fair success.

Salmon are caught occasionally near Eastport, and these are probably Denny's River salmon, although it is quite possible that they are to be referred to the Saint Croix or the Saint John. It is stated on good authority that the drift-net fishery for salmon outside the harbor of Saint John extends very far toward Grand Manan, the boats and nets of the fishermen being sometimes swept by the tide in a single night quite to that point, and sometimes catching salmon there. The salmon caught near Eastport are mostly taken in the herring weirs. Capt. U. S. Treat, who has fished here since 1841, has sometimes taken as many as thirty salmon in his weir; in other seasons but a single salmon. He once took one in January, and found it to be in perfect condition. The same gentleman has found in the stomachs of salmon caught here herring five inches long.* It also occasionally happens that salmon are taken on the hooks of pollack-fishermen. These hooks are baited with herring, and kept near the surface of the water.

5.—LITTLE FALLS RIVER.

This is a very small river near the Denny's. It lies wholly in the town of Edmunds, rises in a small sheet of water called Edmund's Lake, and is not over ten miles in length. Salmon ascend it every year. It has been observed that they enter it from the salt water of Cobscook River in the fall, and competent observers think that this is their ordinary course, very few of them entering the stream in early summer at the ordinary season for the ascent of rivers. That they breed in it is attested by the common occurrence of salmon-parr. They appear to be increasing in numbers.

6.—ORANGE RIVER.

Salmon once frequented this river, but it does not appear that they were ever very numerous. Three dams near the mouth of the river cut them off from all breeding-grounds, and they were exterminated. In 1870 several hundred young salmon, hatched from eggs obtained from the Canadian establishment at Newcastle, Ontario, were placed in this river. In October, 1873, a single salmon was caught at the lower dam and placed in the river above. This is the only specimen seen for many years. The dams are all provided with fish-ways for alewives, and through them it is probable that salmon would ascend at the proper season.

7.—EAST MACHIAS RIVER.

Though better adapted, by its extensive lakes and gentle current, to the production of alewives, this river has always afforded salmon, and

* Captain Treat formerly carried on the salmon fishery at Cape Jellison, Penobscot Bay, but never found fish in their stomachs, nor anything else that he recognized.

formerly they are said to have abounded. Owing to the exertions of the late N. W. Foster, of East Machias, both alewives and salmon were preserved from destruction which almost overtook them about 25 years ago. Several dams had been built on the river, and the fish-ways allowed to fall out of repair. Mr. Foster introduced some improvements in the fish-ways, and prevailed upon his fellow-townsmen to have them kept in order and the laws protecting the fish enforced. A gratifying increase rewarded these efforts, but Mr. Foster was never able to carry out fully his plans of improvement. Some of the fish-ways remained defective, and the greed of the fishermen took too great a share of the ascending fish. There was never, therefore, a complete recovery of the fishery from its depletion.

Salmon-parr are frequently caught with the hook in Chase's stream near the outlet of Gardiner's Lake, and it is inferred that in this stream the adults are accustomed to spawn. No information has been received as to the number of salmon taken in the river recently. Several years since it was estimated at 50 adult salmon annually. Smolts are occasionally taken in the winter by dip-nets, along with tom-cods and smelts.

8.—MACHIAS RIVER.

This river, unlike the East Machias, has a small extent of lake surface, and is not so well adapted to the growth of alewives. For salmon, however, it appears to be much the better stream of the two, and this species is described as having been in old times extremely abundant. There was no market for the surplus, and a ten-pound salmon could be had for fifty cents. Even as late as forty years ago, they are said to have been as plenty as that. A man with a dip-net could take 60 salmon in a day at the lower falls. As in other cases, insurmountable dams were built, and salmon disappeared from the river. For twenty years or more, not one was seen. A weir built for alewives in 1870 and several preceding years never caught a salmon. In 1873, however, they reappeared in considerable numbers. They were first observed in the summer at the ordinary season, below the dams, in the tide-water. Not many were seen at that time, and it is not known that any passed up into fresh water. In September and October they appeared in larger numbers, and made great efforts to pass the lower falls. Many of them succeeded, and some were taken with a dip-net below the dam, and placed above it. The fish-warden observed that part of these salmon were "hook-bills," and part were "round-nosed," from which it may be inferred that the sexes put on their distinguishing marks even when kept in salt or brackish water.*

There are three dams on the Machias River. The first, at Machias village, at the head of tide-water, is not impassable. The second, also at Machias, is a high dam, and completely stops the ascent of fish. It was provided with a Foster fish-way some years ago, but there being

* Letters of M. H. Wilder, esq.

very few alewives in the river and no attempt having been made to introduce salmon, the fish-way was neglected, and went to decay. The third dam is at Whitneyville, five miles above the first This is also too high for salmon to pass. It was provided with a fish-way at the same time as the second dam, and as in that case the structure became useless by neglect.

9.—WESCONGUS, OR PLEASANT RIVER.

About seventy-five salmon are, it is estimated, caught in this river yearly. In 1872 the high state of the water enabled a greater proportion than usual to pass the lower falls at Columbia, where they are usually caught, and reach their breeding-grounds. The catch of that year was consequently light. They are taken altogether with dip-nets, the use of other nets being forbidden by law. One is now and then caught six or seven miles below Columbia Falls, in some one of the weirs built for herring in the estuary into which the river flows. The fishing at Columbia Falls begins about the middle of June and lasts until September; by this time their quality here has deteriorated so that the inhabitants do not consider them edible, and take more pains to give them a passage up the river. They are not supposed to ascend the river more than six miles, where all, or nearly all, of them are stopped by difficult falls. In the spawning season they are frequently seen in a small branch that enters the main river about three miles above Columbia Falls. In size the salmon of this river appear to be not far from the average of other rivers—perhaps a little smaller—"averaging," says my informant,* "from seven to twelve pounds." Occasionally one of five pounds is taken, very rarely one of three pounds, and one smaller than this is hardly ever seen or heard of.

There are six dams across the main river, in height varying from five to seven feet; one of them is out of use. Two of them are in close proximity to each other at Columbia Falls; one of these is provided with a fish-way, and salmon find means to pass them both.

10.—NARRAGUAGUS RIVER.

This river once yielded great numbers of salmon and alewives. They were plenty until forty or fifty years ago. One old gentleman testifies to having once, with the assistance of two others, taken at Cherryfield forty salmon one morning between daylight and sunrise. Other similar feats are told. Small vessels came here to load with fish. Salmon were caught with drift-nets, spears, and dip-nets. They were mostly taken between May first and the middle of July, in the lower part of the river, within a mile of the head of the tide, but they were frequently caught at Beddington Lake, sixteen miles farther up. At the spawning season a great many used to be seen at the mouths of Salmon and Schoodic Brooks, which appear to have been favorite spawning-grounds.

Dams were built in the river at an early day, but until within about fifty years there was none that seriously hindered the ascent of salmon.

* Mr. Gowin Wilson, of Columbia Falls.

A better dam was then built. For a time a fish-way was maintained in it, but it was by and by neglected, and the fish left to their fate. They rapidly diminished, and were in a few years almost utterly extinct. For twenty-five or thirty years, say from 1840 to 1871, but few were seen each season and none taken. For two or three years past more have come, and during the summer of 1873 perhaps two or three dozen were seen trying to pass the lower dam, and four or five of them clubbed to death. An equal number has not been killed in any season for many years.

The number of dams now in existence on the river and branches is eleven, of which four are out of use and falling into decay. Five of the remainder are within a mile of tide-water.*

11.—UNION RIVER.

This was formerly a very productive salmon river, but has not yielded a single specimen for sixteen years.† The fishery used to be carried on with nets. No weirs were ever built in the river;‡ and in the absence of both weirs and nets at the present day it is quite probable that salmon occasionally enter the river in very small numbers without attracting attention. It would be remarkable, indeed, if not a single individual should stray from the Penobscot, which lies so near. Their ascent to their ancient breeding-grounds is, however, effectually prevented by the formidable dams at Ellsworth. Of these there are six, all located within three miles of tide-water. Above them the main river is open to its head-waters.

12.—PENOBSCOT RIVER.

The Penobscot River, besides being the largest between the Saint John and the Connecticut, is distinguished from nearly all others within those limits by the manner in which it discharges its waters into the sea, namely, through a large bay or estuary, narrow at its head, where it receives the waters of the river, but widening gradually to its junction with the open sea. This feature is also characteristic with the Saint Croix, Union, Pawtuxet, and some other smaller rivers, but all the large rivers within the specified limits, with the exception of the Penobscot, discharge their waters abruptly into the sea. This fact may or may not be of importance in its bearing on the distribution and habits of the migratory fishes frequenting the several rivers, but at any rate is not to be neglected.

The estuary of the Penobscot, called Penobscot Bay, has on the seaward side natural limits tolerably well marked, not only by the numerous islands embracing some of large size, that guard its entrance, but by two prominent capes of the main land, Owl's Head on the west, and Waskeag Point on the east. The width of the bay here is nearly thirty

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* Letter of C. J. Milliken, esq.

† Letter of S. Dutton.

‡ Letter of K. K. Thompson.

miles, but it narrows rapidly as we proceed upward, and at Cape Rosier, thirteen miles above, it is only seven miles wide. Above this point it widens a little at Belfast, and then contracts at Fort Point to a width of between two and three miles. Three miles above this is the mouth of the river, which enters the bay by two channels, one on either side of Wetmore Island, sometimes known as Orphan Island, and constituting the town of Verona. The total length of the bay is about thirty miles, being but little more than its greatest breadth. Its area may be roughly estimated at 400 square miles, exclusive of islands. Into this broad bay the Penobscot River discharges about 320 billions of cubic feet of water per year,* or about 873 millions per day. Assuming the mean depth of the bay to be 60 feet, its capacity is 400 millions of cubic feet, and it follows that the volume of fresh water discharged into it is sufficient to renew the whole volume of the bay in a little more than a year. Probably the actual depth is greater than that assumed, and the time required to replace the salt water with fresh would be considerably longer. That part of the bay above Castine, which first receives the water of the river, has an area of perhaps 60 square miles, and, if we assume the average depth to be 8 fathoms, the river could not fill it in less than three months.

These figures are nearly all rough approximations, but they serve to show, in a general way, the small comparative volume of the inflowing fresh water, and prepare us to believe that what with the tides, currents, winds, and other forces tending to bring in fresh supplies of sea-water, the river can exert little influence in changing the constituents of the water, except in the extreme upper end of the bay. The flow of the tide turns the current of the river as far as Bangor in the summer, and above Bucksport always. The water is quite salt at the latter place, and in the summer it is brackish at the former.

The result of the action of the river-water in displacing or altering marine forms of life in the bay, cannot be told with precision without more extensive observations than I have been able to make; but the statement of a few facts will illustrate the degree of its influence.

In several points of the bay are good hake grounds. Off Castine is a good ground for haddock, and cod are also caught in that part of the bay, both of them with their stomachs well filled with marine mollusks and other animals. Near Brigadier's Island is a favorite place for catching menhaden, and this species is common enough in its season about Bucksport. In the smelt-nets set from October to March, on the Bucksport and Verona bridge, there are caught not only smelts and tom-cods but great numbers of flounders, sculpins, skates, &c., and at times, especially in the early part of the season, shrimps and other small crustacea. Jelly fishes are not rare at the same point. The shores, even as far up as this, are covered with a growth of fucus, and species of littorina abound. On the other hand, I cannot recollect of ever seeing a

* Wells's Water-power of Maine, p. 105.

proper fresh-water fish caught in this part of the river or any part of the bay, except a single specimen, caught in Verona, of trout, (*Salmo fontinalis*,) which is known to often run into salt water.

The works of man have interfered less with the migration of salmon in the Penobscot than in any other large river south of the Saint John. Owing to its great volume and other favorable circumstances, dams, quite impassable by salmon, have never been in existence many years at a time. The four points on the lower part of the river at which dams have been built are Veazie, Ayer's Falls, Great Works, and Oldtown. At Oldtown the center of the river has never been closed, and salmon ascend there with considerable ease. At Great Works two long wing-dams, running from the mills on either side up the river nearly parallel with the banks, are joined at their upper ends by a low cross-dam, which is not a serious obstacle at the season of the year when the main body of the salmon are ascending the river. At Ayer's Falls the dam that crosses the river is low, and at its eastern end abuts upon a ledge, over which the water runs down an irregular inclined plane to the level of the main channel below. This assisted the salmon in surmounting the dam, and was; to a certain extent, an abatement of the evil, but at best the structure was so serious an impediment that it was necessary to construct a fish-way, an inexpensive affair, made by merely enlarging a crevice in the ledge at the east end of the dam. The dam at Veazie, built in 1834 or 1835, was at first quite impassable, and so remained for several years. Since then, however, the water has wasted away the bank at the east end of the dam, and disclosed a large crevice in the ledge, through which so large an amount of water is generally flowing that salmon have little difficulty in passing the dam.

Above Oldtown the main Penobscot is entirely free from artificial obstructions for 70 miles; the Mattagamon, or East Branch, for nearly 100 miles; the Mattawamkeag, for 45 miles; the Piscataquis, for 50 miles. Of the tributaries, the lower ones are nearly all effectually closed against salmon by dams, and have been in that condition for many years; in few of them, however, if in any, was the species ever abundant. In the upper tributaries there are comparatively few obstructions, and there the salmon have access to their original spawning-grounds. The dams built there for service in floating timber, or, in the vernacular, "driving" it to the mills below, are generally of such a character that they do not prevent the passage of salmon, and hinder it only for short periods in the spring and early summer. The dam at the outlet of North Twin Lake is of this character. It serves to raise the surface of Ambojegis, Pamedumcook, and the Twin Lakes to a point some thirteen feet above their ordinary level, both for the purpose of facilitating the passage of the "drives" of logs across the lakes, and to store water, to be let out when wanted to float them over the shallow rapids below. The gates of the dam are closed in June, and kept shut for several weeks, while the lakes are filling up. During this time no salmon can

pass. In July they are opened again, and for several weeks more they are pouring out a flood of water, in which salmon can ascend. At the outlet of Chesuncook Lake there is a similar dam, but it is opened much earlier in the season. Such is the case with nearly all driving dams.

Besides the building of dams there is one other artificial change in the condition of the river worth mentioning. For half a century past the principal occupation of the population along the Penobscot River has been the cutting and manufacturing of timber. For this purpose, indeed, most of the dams were built. The refuse from the saw-mills, consisting of slabs, edgings, shavings, and saw-dust, was, until very recently, all thrown into the river, as the easiest way of getting rid of it. Lately the throwing of the coarser sorts of refuse into the river has been forbidden by law; but saw-dust may still legally be disposed of in that way, and the throwing in of refuse of the coarser kinds is not entirely stopped. This practice has not affected the upper part of the river materially, since there are no extensive lumber-mills above Oldtown; but from the latter place to the sea the refuse has accumulated to such an extent as to encroach alarmingly on the channel, and fill up extensive coves and bays with a deposit of decaying saw-dust, mixed with earthy sediment, while great quantities of the former are, through the greater part of the year, to be constantly seen floating on the tide, or swimming at all depths beneath the surface. The extensive deposits have in some instances so altered the configuration of the bottom as to interfere with the success of certain fishing-stations; but beyond that I see no evidence that the discharge of the mill refuse into the river has had any injurious effect on the salmon. It does not seem to deter them from ascending, and, being thrown in below all the spawning grounds, it cannot affect the latter.

The Main Penobscot, above Oldtown, with the exception of two "dead-waters," so called, has, throughout its entire length, a strong current, broken at intervals by falls. The two dead-waters are the Sunkhaze Dead-Water, which commences some two miles above Oldtown and extends from six to eight miles, and a similar one occupying a space between Piscataquis Falls, near the mouth of the Piscataquis River, and Lincoln. The last has a stronger current than the Sunkhaze Dead-Water, and has a gravelly bottom for the most part. The principal falls between Oldtown and Nickerton, at the mouth of the Mattagamon, or East Branch, are the Cook, Olamon, Passadumkeag, Piscataquis, and Five Island Falls. The bottom for the whole distance above Sunkhaze Dead-Water, is rocky or gravelly, though not in many places ledgy. From Mattawamkeag to Nickerton is a beautiful, gravelly bottom, with a uniformly strong current, well adapted, it is supposed, to form spawning-beds for salmon, although it is not positively known that they ever spawn there.

Of the lower tributaries the finest and most extensive breeding-grounds lie in the Piscataquis and its branches, to many of which sal-

mon have access now, visiting them yearly and often showing themselves at Brownville on the Pleasant River. The Passadumkeag probably contains good breeding-gounds, but to a less extent than the Piscataquis. They find suitable ground in some of the tributaries of the Mattawamkeag, and in several small streams directly tributary to the Penobscot. Three of the latter have received the name of "Salmon Stream." In one of them which joins the Penobscot, a few miles above Mattawamkeag, I have, myself, found the nests of salmon.

Above the entrance of the Mattagamon the Main Penobscot, commonly called the West Branch, gradually changes its character, has less gravel, larger bowlders and more ledge in its bottom, and the uniformity of its current is interrupted by numerous falls and extensive lakes; but there is no serious natural obstacle to the ascent of salmon throughout its entire length; and the dams at North Twin and Chesuncook do not wholly prevent salmon reaching the upper waters. At both these dams they are frequently seen and sometimes caught. One informant has known of two instances, in a single spring, of salmon throwing themselves upon the piers at Chesuncook Dam, and being taken by the rivermen.* Of the tributaries of this part of the Penobscot, the Millinocket, Nahmakanta, Souadnehunk, Caribou, and Caucomgomoc Streams are particularly well fitted to be the breeding-grounds of salmon.

It is believed that the Mattagamon or East Branch is a better salmon-river than the Main Penobscot, and that a much greater number of salmon resort to it. They can ascend it as far as Grand Falls, thirty-five miles from its mouth, and find extensive spawning-grounds not only in the Mattagamon itself, but in the Wassaticook and Seboois Streams and their tributaries. The Wassaticook is an impetuous mountain-stream, draining the northern and eastern sides of Mount Katahdin. The Seboois traverses a more level district, and is a very fine, gentle, gravelly stream, with numerous rapids of sufficient force to form admirable spawning-beds. In this stream and in the Mattagamon I have, myself, seen many salmon-nests.

The industrial modes of fishing employed in the Penobscot Bay and river are three: first, drift-nets; second, pound-nets; third, weirs. With very few exceptions the use of each mode is confined to a particular district. Drift-nets are used only in the swift water of the river above the flow of the tide; pound-nets in the more open parts of the bay; weirs in the tidal part of the river and the upper part of the bay.

The drift-net is a simple straight net, buoyed on the upper, and and weighted on the lower edge, which is thrown out from a boat and allowed to float down the current, intercepting any upward-bound salmon that may come in the way, and which are caught by thrusting their

*Mr. Manly Hardy, of Brewer, is authority for this statement, as well as for numerous others in relation to the Upper Penobscot. Mr. Hardy says that he knows of a salmon, weighing half a pound, being taken on a fly-hook more than thirty miles above Chesuncook in September, 1873.

heads into the meshes in the endeavor to break through the net. A considerable number of these nets are every summer in use on the shallow rapids below the Great Works, Basin Mills, and Veazie dams. Occasionally one of them is used at some point above Oldtown. The Mattagamon, near the mouth of the Wassaticook, is one of these points; the North Twin dam is another.

The pound-net, in use on the Penobscot, consists of the "run," the "inner pound," and the "outer pound." The run is a straight net, running out into the water at right angles to the shore. It is 11 or 12 feet deep, and its length depends somewhat on the character of the site; 25 fathoms is the common length, but in very "bold" water 18 or 20 fathoms will answer. At the extremity of the run is the inner pound, which is shaped like an obtuse arrow-head, the two barbs being styled "hooks." The entrance of this inner pound, 6 feet wide, is between the barbs or "hooks," and at its tip is an opening 1 foot wide, which leads into the outer pound, an inclosure about 18 feet square. Both pounds have bottoms, and are of the same depth as the run, 11 or 12 feet. The whole is supported by wooden floats, so that it rises and falls with the tide, and is held in place by anchors planted at the extremities of long "warps." A pole placed perpendicularly at the point of each hook, and another at the outer angle of the outer pound, brace the bottom down. The latter is called the "spring-pole," and, in "springing" the net, it is cast loose at the upper end and allowed to swing loose while the bottom of the pound is drawn up. The mesh employed is 6 or 6½ inches long, being 3 or 3¼ inches square. The 6½-inch mesh is too small to mesh a 22-pound salmon and too large to catch one of 6 pounds. It is supposed that if small salmon ever enter these nets, they pass out through the meshes. The majority of the medium-sized and large salmon do not mesh but remain free in the pound, being too wary to strike the meshes. The bottom of the net is commonly several fathoms above the ground; and were not the salmon that encounter its run persistent surface-swimmers, they would dive under it, and escape without entering the pounds.

The three parts first described constitute what the fishermen call a "hook of nets." Sometimes from the outer extremity another "run" is set, with pounds at the end of it, constituting another "hook of nets," and this combination is termed a "gang of nets." Sometimes as many as four hooks are set in a single gang.*

The invention of this style of net is ascribed by the fishermen to one Halliday, an Englishman. The net in use before it had only one pound, corresponding to the inner pound. It was much inferior to the modern style, as a great many salmon escaped by the entrance, which had to be wide to induce them to enter at all, and in this way the very largest salmon were lost, being too large to mesh.

A Penobscot fish-weir generally consists of a leader and three pounds.

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* Illustrations of these nets are given in the appended plates.

The "leader" corresponds with the run of the pound-net described above. It is built of stakes and brush loosely driven. Its length is governed by the shape of the river-bed and some other circumstances, such as the character and direction of the currents. Most fishermen aim to have their pounds located entirely beyond low-water mark, and frequently the water where they are situated is 15 or 20 feet deep when the tide is out. The leader extends thence to the shore. The first or great pound is a heart-shaped inclosure, about 60 feet wide, having an entrance 22 feet wide, nearly in the middle of which is the outer end of the leader. Stakes and brush compose the walls of the great pound. At the apex of this inclosure is an entrance 3 or 4 feet wide to the second pound, which resembles the first in shape, but is commonly provided with a board floor near low-water level, and has walls of netting instead of brush. An opening only a foot wide leads into the fish-pound, which is also provided with a floor.* Fish swimming along the shore, whether ascending or descending the river, encounter the leader, and in trying to get around it are led into the great pound, and the shape of this is such that they rarely escape out by the way they came in, but readily find the entrance to the next pound, from which, in like manner, they pass on to the fish-pound, where they are left by the retreating tide on the bare floor.

Both weirs and pound-nets depend for their success on the disposition of fish to move in straight lines when there is no obstacle in the way. On being turned from their course by the leader, they swim, in the direction it gives them, straight into the great pound, whose entrance is so wide that they see only one side of it at once. Were the opposite side of the entrance or of the pound in sight, the fish might be deterred from entering and turn back. Once within the great pound, they swim straight to the opposite side, meeting which, they turn and follow it. If frightened at the narrowness of the passage into the second pound, they turn back and follow the side of the great pound back toward the entrance, but by the time they reach that point the curve of the pound has given them a new direction, which carries them directly past the entrance. Thus they rarely find their way out, and, becoming soon familiar with the walls of their inclosure, venture through the gap that leads them into the second pound.

The weirs of the Penobscot are not very expensive. It is estimated that one can be maintained at a cost of $60 a year. They generally occupy the same site year after year. The site is fixed by experience in each individual case, and hardly any rule can be given that will guide in the selection of one on an untried shore. There are long stretches of shore where no one attempts nowadays to build weirs, but in most cases these sites have been tried in former times and found unprofitable. Weirs are built in the river as early in the spring as the state of the water will permit, and are for the most part in operation before the close

* See illustration in the appended plates.

of April. On the shore of the bay they are built a little later, the salmon not making their appearance so early as in the river.

The district within which these weirs are almost the sole mode of taking salmon extends from Orrington, on the river, to Belfast, on the west side of the bay, and Castine on the east side; and with a very few exceptions no weirs have ever been built outside those limits. The number built within this district in 1873 was 114, of which all but one caught salmon. In 1870 there were 160 weirs, of which five or six caught no salmon, depending for their profits on the capture of menhaden and alewives. The last season having been a profitable one, a greater number of weirs will be built in 1874. Thus the number varies from year to year.* In some parts of the river as many weirs are built now as ever, while in other localities there has been a marked falling-off.

The limits within which salmon-fishing is regularly carried on as an industry in the Penobscot River and Bay at the present day, may be fixed at Oldtown above, and at Rockport, Long Island, and Castine below. Many years ago there were fisheries on the eastern side of the bay as far out as the upper or northwest end of Eggemoggin Reach and at the extreme lower end of Long Island. But these outer stations were not profitable, and were abandoned after a few years' trial. One at Buck's Harbor yielded about fifty salmon a year. One near Cape Rosier was more productive, and the last year it was in operation yielded 102 salmon.

For the last two years (1872 and 1873) a weir for the capture of herring has been maintained on Western Pond Island, about two miles below Cape Rosier. It caught 30 salmon in 1872 and only 8 in 1873. It is probable that, were similar weirs maintained in favorable places still farther down the bay, salmon would be taken in them in small numbers. I have learned of the existence of only one weir in any part of the bay outside of Long Island and Rockport. This is a weir built for the capture of alewives at the outlet of Fresh Pond in North Haven. In former times there have been weirs maintained at five or six different points on the same island for the capture of herring and mackerel;† but I cannot learn that a salmon was ever caught there. This fact, however, is not a fair test of the presence of salmon in those waters, since the structure and location of the weir are not favorable for their capture Probably the salmon caught was a native of the Penobscot; for all the breeding-grounds of the Union River, to which we should naturally refer it, have for many years been inaccessible.

The capture of salmon in the Lower Penobscot Bay and in the open sea adjoining, with nets and hooks, is of rare occurrence; but there are several instances worthy of record. Off the northeast breaker of Seal

* On the appended map of Penobscot Bay and River are represented all the weirs of which I have obtained information, both those built recently and many that were abandoned years ago.

† Statement of A. Waterman.

Rock, a certain Captain Eldridge, of Bucksport, caught a salmon on a hook while "drailing" for pollack; that is, dragging a seven or eight fathom line with a baited hook after a schooner under sail. This was over fifty years ago, when salmon were plenty in the Penobscot, yet it was considered a great wonder; and the old gentleman who told the story,* though he was seventy-six years of age, and had been all his life engaged in fishing, had never heard of another instance of the kind. There are several stories of salmon being taken on trolling-lines, but no exact statements in regard to those occurrences have been obtained. Inhabitants of the island of Matinicus, fifteen miles seaward from Owl's Head, report that salmon are sometimes taken in seines drawn for mackerel in that vicinity.

About eight years ago, in the month of July, a small salmon, (grilse,) weighing two or three pounds, was caught by Mr. William L. Howe, of Lincolnville, in a net set for menhaden at Wooden Ball Island,† which lies between Matinicus and Seal Rock, and is therefore but a few miles from the locality where the salmon was caught on the pollack-hook, as stated above.

On the western shore of the bay, salmon-fishing begins about seven miles above Owl's Head, at Rockport, where it has been regularly carried on for more than sixty years. For many years past, four nets have been set there. For the past five years the fishery of 1873 was the best; that of 1871 and 1872 the poorest. The average of late has been about 150 salmon a season in all of the nets; this is pronounced a small catch in comparison with that of years ago.†

Above Rockport there are no salmon-fisheries up to a point below the harbor of Camden, where two nets are set. From this point northward, within ten miles, there were, in 1873, twenty-one gangs of nets, comprising thirty-seven hooks. The greater part of these are in the town of Lincolnville, and a large number of them are crowded into the small bight into which empties Duck Trap Stream.

The most northerly net-berth is in the town of Northport. In all, there were set along the western shore of the bay forty-three hooks, in twenty-seven separate gangs. The whole number of salmon caught in them in 1873 was 1,561,‡ being an average of 36.3 a hook, and of 58 a gang.

The best catch was 175 salmon in three hooks, and the poorest 12 salmon in two hooks.

In the vicinity of French's Beach, Lincolnville, the nets are generally set about May 10, and taken up early in July. It is within these dates only that fishing is generally profitable. Some fishermen catch consid-

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* James S. Collins, of Castine.

† Letter of H. H. Page.

‡ The most of the data of this statement were furnished me by Ayres & Miller, fish-dealers of Camden. Mr. Job Pendleton, of Lincolnville, from entirely separate but less complete data, estimated the catch at a little over 1,583.

erable numbers of salmon both earlier and later; but whether their success is owing to exceptional situations or to lack of competition is a matter of doubt. It is believed that salmon can be caught each year earlier near the mouth of Duck Trap Stream than at any other point in the western bay, and this alleged fact is attributed to the attraction of the fresh water.

In the middle of the bay the capture of salmon is followed every year on Long Island at twelve or fifteen stations scattered along its western side. Nets alone are now used. A single weir was built at the southern extremity of the island, for about ten years, ending in 1868. About thirty salmon a year were caught in it. Like ordinary salmon-weirs, it was made of netting fine enough to catch herring, and besides these it took also menhaden and mackerel. On the western side of the island no salmon-nets are set. The reason for their absence I have not investigated, but the land slopes down the shore more gradually on that side than on the other, and it may be inferred that there is a corresponding difference in the inclination of the bottom, which may affect either the course of the salmon in their migrations or the facilities for setting and working nets.

In Belfast Bay no salmon are caught within four miles of the port of Belfast on the north shore, and 14 miles on the south shore; so that from the upper limit of the net-fishery there is a reach of 18 miles where no salmon-fisheries are carried on. The fishery begins again near the harbor of Searsport. Here, and at all points above, it is carried on with weirs instead of nets. The yield is much better than it is in the net-fishing below. This may in part be attributed to the greater efficiency of the weirs, but I think, after making all allowances on that score, there is still a difference that can only be attributed to the presence of a greater number of salmon near shore. The weirs on Sear's Island and on Cape Jellison are among the most productive in the whole bay and river. In 1873 there were fewer weirs built here than usual; on Sear's Island only one instead of six, and on the south side of Cape Jellison only seven instead of ten. It may be mentioned, as illustrating the vicissitudes of the business as well as the occasional irregularities of the movements of the salmon, that while some of the weirs on the south side of Cape Jellison caught fewer salmon than ordinary, one on the west side, in Stockton Harbor, (No. 61,) caught twice as many.* The average catch of the former in 1873 was 91 salmon a weir.

It is worthy of remark that the weir that had such exceptional luck was built on a gently-declining bottom, with a long leader, and was in a somewhat sheltered position, while the others were built on a steeply-inclined shore at the base of a precipitous bank, with short leaders, and exposed to the force of southerly and easterly storms, which sometimes render these weirs almost inaccessible. The bottom is, for the most

* Letter of James M. Treat.

part, so hard that considerable parts of the weirs are supported by stakes, not, as in ordinary cases, driven in the ground, but planted like masts in great wooden frames, which are sunk and kept in place by a heavy ballasting of stone.

On the east side of the bay, opposite Cape Jellison, is a shore much better adapted to the construction of weirs in the ordinary way, having a gentle slope and a bottom of only moderate hardness. This is known in the vicinity as the "Dashen shore," and includes all the shore in the town of Penobscot and all in Castine except those in the harbor. Its salmon-fishery has not so high a reputation as that of Cape Jellison. In 1873 the catch was larger than usual, averaging 83 a weir. At the same time the three weirs in Castine Harbor, which are generally among the best in the whole bay or river, caught far fewer than usual, averaging only 69 a weir. Thus the experience of the Cape Jellison fishermen is repeated. Weirs on a gently-sloping shore with a western exposure have a successful season, while those on a steep shore with an easterly exposure are unsuccessful. The number of weirs built on the Dashen shore in 1873 was 23. In two cases two weirs were built on the same hedge; all of the others were on separate hedges. Thus there were 21 hedges. In 1870 there were 24 hedges and 33 weirs. The decrease in number was doubtless owing to the poor success of the fishery in that and the two following years. With the salmon are taken, in these weirs, herring, menhaden, shad, and alewives. The herring and menhaden are quite irregular in their occurrence; alewives have been decreasing in numbers for many years; and shad have almost disappeared.

Penobscot River enters the bay by two mouths, on either side of Wetmore Island. The western is the main channel, and the route by which by far the greater portion of the salmon enter the river. Its shores are for the most part bold, and at the "Narrows" the water in mid-channel is about ten fathoms deep, which exceeds by two fathoms the general depth of that part of the bay west and north of Long Island. This increased depth is doubtless owing to the strength of the tides, which sweep with great force through a narrow channel. The approach to the Narrows is a tunnel-shaped estuary two miles wide at its entrance opposite the southern extremity of Wetmore Island. On both sides of this estuary, salmon-fishing is carried on extensively. As the width of the river decreases the number of weirs increases, and just below the narrowest point there have been eight or ten built within a single mile on the west shore. These weirs have short leaders, and in many cases the entrance to the second pound is on the upper instead of the outer side of the first pound.*

In general, the season of 1873 was a very successful one with the fishermen of this district; yet several weirs, most of them in the Narrows, had exceptionally bad luck.

* This is the second style of Penobscot salmon-weirs, represented in the appended illustrations.

The eastern mouth of the river is of a different character, discharging a much smaller volume of water, which is mainly received from the main Penobscot by the Thoroughfare, a broad, shallow passage around the north end of Wetmore Island, but is considerably augmented in the early part of the season by the water of Eastern River. The latter is not a salmon-stream, but is the principal nursery of the alewife, which finds in its many ponds admirable breeding-grounds. It flows to its junction with the Thoroughfare through a broad estuary, in which its scanty waters are insufficient to delay long the setting-in of the upward current that accompanies the flood-tide; while in the Penobscot and in the Thoroughfare the current sets down near two hours after low water. Hence we have the phenomenon of a down-current in the Thoroughfare at the same time that there is an up-current in the estuary of Eastern River, and the water from the former fills the latter for some distance above the point of junction. This is a sufficient explanation of the fact that while the salmon rarely attempt to ascend Eastern River, those that come in by the eastern mouth passing into the main Penobscot through the Thoroughfare, yet they frequently pass the mouth of the latter and are caught in weirs some distance up the estuary of Eastern River. Thus, in 1873, No. 185 (see appended map of fisheries of Penobscot Bay and River) caught 60 salmon, and No. 168 caught 30. This explanation accords well with the theory that salmon find their way back into their native rivers, not through any knowledge of topography but by recognizing in some way the qualities of the water. In the weirs of Eastern River farthest up salmon are seldom caught; and indeed neither in any portion of it, nor in the Thoroughfare, nor in the common river below, is the catch at all to be compared with that in the western channel of the Penobscot.

Above the port of Bucksport but few weirs have been built for many years, and the number has of late diminished. In 1870 there were 15; in 1873, only 9. The latter year was quite profitable, the increase in the number of salmon being remarkable. Three weirs in Marsh Bay caught 250 salmon, 5 shad, and 6 barrels of alewives. Weir-fishing has never been practiced in the Penobscot above Orrington. It is, however, known that as early as 1780 there was a rude half-tide weir in the town of Hampden.

Within this district, on the eastern side of the expansion of the river called Marsh Bay, are Dram Point Flats, the history of whose fisheries is very interesting. In 1812 there was a single half-tide weir built on these flats; it was of triangular shape, one side being formed by the shore and the other two being built of stakes and brush. On the up-river side the brush-work was built higher than high-water mark. The down-river side, which, however, was exposed to an eddy-current on the ebb-tide, was, for the outer half of its length, built to an equal height with the upper side, while the part next the shore rose only to half-tide mark. Over this low part of the inclosure the fish swam at

high water. Left inside by ebbing of the tide, they would gather in a small compartment at the outer corner, whence they were dipped by the fishermen. This was the highest style of contrivance for the capture of fish then in use on the Penobscot. It took immense quantities of shad and alewives.

The first trap-weir was built in 1815 at Treat's Point, on the west side of Marsh Bay, built by one Hollis Emerson, from the Kennebec. It worked on the same principle as those now in use, but had only one pound. In 1816 a similar one was built on Dram Point Flats. The new weirs were so successful that large numbers of them were built all along the river immediately. In 1820, however, and for several years thereafter, fish were scarce. In 1822 only two weirs were built on Marsh Bay, one on Dram Point Flats and one on the opposite side. That year was a very poor one with the fisheries in this part of the river, but was better in the bay and as far up the river as the northern end of Wetmore Island, there being an extraordinary catch of salmon about the 1st of July. From 1822 to 1836 there was an improvement in the river-fisheries, especially in the salmon-fishery. The year 1836 was marked by a great run of salmon.

In the appended illustrations are two plans of Dram Point Flats,* representing the fish-weirs built on it; the one in 1832, the other in 1873. In 1832 there were, on this short stretch of shore less than a mile long, five fishing-stations, maintaining 17 weirs, each with several pounds. No exact statistics in relation to their yield can be obtained, but it is described as being enormous. Alewives were sometimes so plenty as to be given away by the cart-load. The most of the fish were shipped on small vessels that came from Portland and Southern New England to buy.

One of the men in this business† states that he remembers of six vessels being there at one time loading; they would probably carry away fish to the value of $37,000, and this but part of the season's catch.

The prices of those ladings were, for salmon, 5 to 7 cents a pound; for shad, $6 to $7 a barrel; and for alewives, $2½ a barrel.

In 1873, instead of the seventeen weirs, there were only three, and these probably were less productive than the same number of weirs in 1832. It should be remarked that the abandonment of these fisheries was due more to the loss of the shad and alewife fishery than to the decrease of the salmon. It is not, therefore, to be inferred that a similar falling off in the fishing-industry has occurred in districts where the salmon-fishery was relatively of greater importance. Another source of injury to the fisheries is the deposit of sawdust and mud on the flats. It will be observed that in 1873 the flats extended considerably farther into the

* These plans and accompanying facts were furnished by Mr. John Arey, of Bucksport. The preceding statements about the fluctuations of the fisheries are on the authority of Mr. Amos Treat, of Frankfort.

† Mr. Frederick Twombly, of Portland.

bay than in 1832. This is caused mainly by the accumulation of sawdust, which has not only moved the low-water line farther out, but has greatly lessened the depth of the water for a long distance outside of this line.

13.—TABULAR STATEMENT OF THE CAPTURE OF SALMON ON THE PENOBSCOT RIVER.

The following statement of the number of salmon caught in 1873 is based, for the most part, on the statements of the fishermen themselves; the number caught in each weir and net having been reported in nearly every case:

TABLE XII.—*Statement of salmon caught in Penobscot Bay and River in* 1873.

District.	Implements.	No. of salmon.
Rockport to Northport	Pound-nets; 27 gangs, comprising 43 hooks	1, 561
Long Island and Western Pond Island	Pound-nets; 14 gangs, comprising 17 hooks and 1 weir.	1, 008
Castine and Penobscot	26 weirs	2, 143
Orland	7 weirs	378
Searsport and Stockton	35 weirs, 1 gang-net	3, 377
Verona, (Wetmore Island)	30 weirs	2, 468
Bucksport, Prospect, and Winterport	15 weirs	771
Bangor to Oldtown	Drift-nets, number unknown	1, 984
Totals	114 weirs, 42 gangs of nets, &c	13, 690

Nothing is known of the number of salmon caught above Oldtown. A due allowance for this omission, and for certain fishing-stations where it was impossible to obtain correct statements, would probably swell the total to 15,000 salmon.

In comparison with the yield of many preceding years, this is a very large increase; though unfortunately, in the absence of data for an exact estimate, no very precise statement can be made as to the degree of increase. At Rockport, the past season was the best since 1868, the catch of four nets being 300 salmon in 1868, 130 in 1870, and 190 in 1873.* In Camden and Lincolnville it was better than usual. On Long Island the catch was one-third above the average.† The two weirs in Searsport were comparatively unsuccessful, while the single one on the western side of Sear's Island did much better than usual. On the west side of Cape Jellison, as has been already stated, salmon were caught in greater numbers than usual, while some of the weirs on the south side caught fewer.‡ In Castine Harbor the catch was far below the average, while from this point up the east shore of the bay it was considerably above average. In all parts of the river, except here and there a weir, the increase was very marked. In the vicinity of Bucksport it is commonly

* Statement of J. McIntire.

† Statement of Benjamin Ryder.

‡ Statement of James M. Treat.

thought to have been the most successful season for twenty years. An inspection of the record of weirs Nos. 161 and 162, at the south end of Wetmore Island, (given below,) shows that it was the most successful season during all the time (eighteen years) covered by the record. In some localities, where in ordinary years very few salmon are caught, they appeared in large numbers. The drift-nets above Bangor were unusually successful; and after all the decimation the ranks of the salmon suffered on the way, an uncommonly large number was observed on the upper waters and near the breeding-grounds.

The following statement exhibits the yield, for thirteen years, of two of the best weirs on the Penobscot, the owner of which (Hon. A. H. Whitmore, of Verona) has with commendable public spirit offered it for publication. Each entry is made at the time of sale, and includes all the salmon caught since the previous sale:

TABLE XIII.—*Record of salmon sold* from weirs Nos.* 161 *and* 162, *south end of Wetmore Island.*

Date.	Number of salmon.	Aggregate weights.	Average weights.	Date.	Number of salmon.	Aggregate weights.	Average weights.
1860.				1860.			
April 21	1	18½	18.5	June 19	2	31	15.5
April 30	1	16¾	16.7	June 21	4	79½	19.8
May 1	1	25¾	25.7	June 23	5	71	14.2
May 9	1	21½	21.5	June 25	19	229	12.0
May 12	2	33	16.5	June 26	2	17	8.5
May 14	2	18½	9.2	June 27	4	47	11.7
May 17	1	17½	17.5	June 30	8	98½	12.3
May 18	3	33	11.0	July 1	4	39½	9.8
May 22	2	29½	14.7	July 2	5	56½	11.3
May 24	2	21½	10.7	July 5	4	43½	10.8
May 26	9	109	12.1	July 11	2	....	....
May 30	7	120	17.1				
May 31	7	87	12.4	SUMMARY.			
June 4	1	11	11.0				
June 7	10	122	12.2				
June 8	2	20	10.0	April	2	....	17.6
June 9	11	146	13.2	May	37	....	13.9
June 11	9	105	11.6	June	107	....	11.9
June 14	12	145	12.0	July	15	....	10.7
June 15	6	72	12.0				
June 18	12	172	14.3	Total	161	....	12.3

Date.	Number of salmon.	Aggregate weights.	Average weights.	Date.	Number of salmon.	Aggregate weights.	Average weights.
1862.				1862.			
May 5	2	38	19.0	July 3	12	150	12.5
May 18	1	19½	19.5	July 13	24	244	10.2
May 19	3	59	19.6	July 20	1	11½	11.5
May 22	1	19¾	19.7	July 25	3	32½	10.8
May 24	6	77	12.8	August 5	2	25¼	12.6
May 25	1	9	9.0				
May 26	2	21	10.5				
May 29	2	28	14.0				
June 2	4	38	9.5	SUMMARY.			
June 9	7	102½	14.6				
June 12	12	156	13.0				
June 14	4	34½	8.6	May	18	271¼	15.0
June 19	7	116	16.5	June	97	1,175	12.1
June 23	19	239½	12.6	July	48	526¾	10.3
June 26	14	159½	11.4	Aug	2	25¼	12.6
June 30	30	329	10.9				
July 1	8	88¾	11.0	Total	165	1,968¼	12.1

* These salmon were sold within a few days after catching, commonly within three days.

Record of salmon sold from weirs Nos. 161 *and* 162, *south end of Wetmore Island*—Cont'd.

Date.	Number of salmon.	Aggregate weights.	Average weights.
1863.			
May 14	1	8¾	8.7
May 25	2	29	14.5
May 28	9	103	11.4
May 30	6	75	12.5
June 1	9	111¾	12.4
June 4	4	43	10.7
June 6	9	102	11.3
June 11	5	44	8.8
June 13	10	106	10.6
June 15	5	56	11.2
June 18	8	77	9.6
June 22	14	137½	9.1
June 25	12	124½	10.3
June 27	10	107¾	10.7
June 29	10	82	8.2
July 2	24	250	10.4
July 3	6	55	9.1
July 4	1	8	8.0
July 5	2	22	11.0
July 7	3	27½	9.1
July 9	11	120	10.9
July 13	26	160¼	6.1
July 15	2	18	9.0
July 17	5	49½	9.9
July 18	3	27½	9.1
July 22	4	46¾	11.6
July 24	5	46	9.2
July 27	1	9¾	9.7

SUMMARY.

	Number of salmon.	Aggregate weights.	Average weights.
May	18	....	11.9
June	96	....	10.3
July	93	....	10.1
Total	207	....	9.8

Date.	Number of salmon.	Aggregate weights.	Average weights.
1864.			
May 9	1	18	18.0
May 10	2	34½	17.2
May 11	1	20	20.0
May 18	1	10	10.0
May 21	2	27¼	13.6
May 26	3	38½	12.8
May 30	5	85½	17.1
June 2	3	35½	11.8
June 4	5	65	13.0
June 6	5	49½	9.9
June 9	4	35½	8.8
June 11	3	35½	11.8
June 13	10	113¼	11.3
June 16	13	164	12.6
June 18	6	81	13.5
June 20	1	6	6.0
June 23	7	98	14.0
June 24	5	50	10.0
June 27	6	63½	10.5
June 30	9	107	11.9
July 2	5	46½	9.3
July 4	2	16½	8.2
July 7	2	23¼	11.6
July 6	2	16½	8.2
July 9	2	17	8.5
July 11	5	80½	16.1
July 23	1	7	7.0

SUMMARY.

	Number of salmon.	Aggregate weights.	Average weights.
May	15	....	15.5
June	77	....	11.7
July	19	....	10.9
Total	111	....	12.1

Date.	Number of salmon.	Aggregate weights.	Average weights.
1865.			
April 17	1	13¾	13.7
May 6	1	18	18.0
May 18	1	18	18.0
May 22	3	28¼	9.4
May 24	3	40	13.3
May 29	2	19	9.5
June 1	2	28	14.0
June 5	3	44½	14.8
June 8	12	194	16.1
June 10	6	66½	11.0
June 11	1	11¼	11.2
June 12	7	94	13.4
June 15	3	33	11.0
June 19	18	196	10.8
June 22	10	118½	11.8
June 26	16	200	12.5
June 28	9	105	11.6
June 29	19	115	6.0
July 1	16	172	10.7
July 3	9	107	11.8
July 4	14	140½	10.0
July 6	3	30	10.0
July 7	3	32	10.6
July 10	3	26½	8.8
July 14	1	9¾	9.7
August 4	1	16	16.0
August 5	1	10	10.0

SUMMARY.

	Number of salmon.	Aggregate weights.	Average weights.
April	1	....	13.7
May	10	....	12.3
June	106	....	11.3
July	49	....	10.5
August	2	....	13.0
Total	168	....	11.2

Record of salmon sold from weirs Nos. 161 *and* 162, *south end of Wetmore Island.*—Cont'd.

Date.	Number of salmon.	Aggregate weights.	Average weights.
1866.			
April 22	5	66½	13.3
May 17	5	70	14.0
May 24	3	33¾	11.2
May 28	4	42	10.5
May 29	4	49¼	12.3
May 31	2	16	8.0
June 2	6	61¼	10.2
June 8	4	31¼	7.8
June 11	13	147½	11.3
June 14	8	83¼	10.4
June 15	5	75¼	15.0
June 18	10	105½	10.5
June 21	17	213	12.5
June 23	8	103½	12.9
June 25	19	205	10.7
June 26	7	62½	8.9
June 27	6	62	10.3
June 30	1	8¾	8.7
July 2	4	30¼	7.5
July 3	5	57	11.4
July 5	4	34	8.5
July 10	1	9	9.0
July 12	2	19	9.5
July 15 to 25	14	151	10.7

SUMMARY.

	Number of salmon.	Aggregate weights.	Average weights.
April	5	....	13.3
May	18	....	11.7
June	104	....	11.1
July	30	....	10.0
Total	157	....	11.0

Date.	Number of salmon.	Aggregate weights.	Average weights.
1867.			
April 27	1	18	18.0
May 3	1	20½	20.5
May 13	4	69	17.2
May 16	1	19	19.0
May 21	1	15	15.0
May 23	5	66	13.2
May 27	13	138	10.6
May 30	5	55½	11.1
June 1	13	161	12.3
June 3	11	134¼	12.2
June 6	10	110	11.0
June 8	4	57	14.2
June 10	17	190½	11.2
June 12	28	321½	11.4
June 15	20	254	12.7
June 17	32	383	11.9
June 18	3	28¼	9.4
June 19	19	231	12.1
June 20	1	9	9.0
June 22	9	90	10.0
June 24	20	233	11.6
June 25	6	53¼	8.8
June 27	21	239½	11.4
June 28	12	112	9.3
July 1	17	150	8.8
July 3	3	31	10.3
July 4	3	35	11.6
July 6	1	10	10.0
July 10	1	9	9.0
July 13	5	52½	10.5
July 21	1	11	11.0

SUMMARY.

	Number of salmon.	Aggregate weights.	Average weights.
April	1	....	18.0
May	30	....	12.7
June	226	....	11.5
July	31	....	9.6
Total	288	....	11.4

Date.	Number of salmon.	Aggregate weights.	Average weights.
1868.			
May 9	1	21½	21.5
May 14	1	19½	19.5
May 18	2	30	15.0
May 22	3	50½	16.6
May 26	2	21	10.5
May 27	1	10½	10.5
May 28	4	51	12.7
June 1	6	81	13.5
June 4	7	78½	11.2
June 4	9	128½	14.2
June 6	15	177	11.8
June 8	7	73½	10.5
June 9	1	7½	7.5
June 10	4	54	13.5
June 12	15	177	11.8
June 13	6	66½	11.0
June 14	5	70	14.0
June 16	17	245	14.4
June 17	9	116	12.8
June 18	11	132¾	12.0
June 19	10	126¾	12.6
June 20	4	53¼	13.0
June 23	4	45	11.2
June 25	1	8	8.0
June 26	2	37½	18.7
June 28	8	113	14.1
June 29	14	165	11.7
July 1	22	240¼	10.9
July 2	5	52¼	10.4
July 3	4	48¾	12.0
July 5	8	104	13.0
July 7	8	85¾	10.6
July 9	4	53¼	13.3
July 12	12	132	11.0
July 15	5	51	10.2
July 16	4	43¾	10.9
July 19	5	62½	12.5
July 31	5	54	10.8
August 2	1	10½	10.5
August 7	1	9¾	9.7
August 10	3	24	8.0
August 12	1	8½	8.5

SUMMARY.

	Number of salmon.	Aggregate weights.	Average weights.
May	14	....	14.5
June	155	....	12.6
July	82	....	11.3
August	6	....	8.7
Total	257	....	12.1

Record of salmon sold from weirs Nos. 161 *and* 162, *south end of Wetmore Island*—Cont'd.

Date.	Number of salmon.	Aggregate weights.	Average weights.	Date.	Number of salmon.	Aggregate weights.	Average weights.
1869.				1869.			
April 17	1	19¾	19.7	June 27	9	98	10.8
April 21	1	18¼	18.2	June 29	5	59	11.8
April 29	2	37½	18.7	July 3	5	42½	8.5
April 30	1	17½	17.5	July 4	6	55¾	9.2
May 3	3	55½	18.5	July 5	5	54¼	10.8
May 13	1	....	....	July 7	2	17¾	8.8
May 16	1	18	18.0	July 9	3	28¼	9.4
May 24	1	9¾	9.7	July 11	4	41½	10.3
May 26	2	32¾	16.3	July 12	14	161	11.5
May 30	1	7½	7.5	July 14	5	53¼	10.6
June 2	2	36½	18.2	July 15	2	25	12.5
June 4	1	10½	10.5	July 17	2	30½	15.2
June 6	7	85¼	12.2	July 23	1	8¼	8.2
June 8	1	10¼	10.2				
June 11	15	207	13.8				
June 13	8	90½	11.3	SUMMARY.			
June 15	4	45	11.2				
June 16	2	20½	10.2				
June 17	3	36½	12.1				
June 18	9	111	12.3	April	5	....	18.6
June 19	1	8	8.0	May	9	....	15.4
June 20	6	59½	9.9	June	88	....	12.1
June 22	4	44½	11.1	July	49	....	10.5
June 24	5	65	13.0				
June 25	6	81	13.5	Total	151	....	12.0

Date.	Number of salmon.	Aggregate weights.	Average weights.	Date.	Number of salmon.	Aggregate weights.	Average weights.
1870.				1870.			
April 19	1	21½	21.5	July 3	2	23¾	11.8
April 27	2	29¾	14.8	July 4	5	67½	11.0
May 11	1	17	17.0	July 5	2	24	12.0
May 12	1	14½	14.5	July 8	3	36	12.0
May 18	2	28½	14.2	July 12	1	10	10.0
May 19	1	10	10.0	July 15	1	11	11.0
May 20	4	57¾	14.4	July 16	1	10	10.0
May 23	1	19	19.0	July 18	2	30	15.0
May 25	2	31½	15.7	July 22	2	23¼	11.6
May 26	1	12½	12.5	July 26	1	9¼	9.0
May 27	5	81	16.2	August 2	4	39	9.7
June 1	5	59¼	11.8	August 4	2	20	10.0
June 2	7	88½	12.6	August 5	1	10¾	10.7
June 6	17	226	13.2	August 7	1	10	10.0
June 7	7	115½	16.5	August 10	1	10¾	10.7
June 9	5	57	11.4	August 11	2	18¾	9.3
June 12	3	43	14.3	August 12	1	10	10.0
June 13	1	14	14.0	August 18	3	22½	7.5
June 14	1	10	10.0				
June 15	9	124	13.7				
June 16	4	65	16.2				
June 17	3	41	13.6	SUMMARY.			
June 20	23	298	12.5				
June 22	7	97	13.8				
June 24	13	198½	15.2	April	3	....	17.0
June 25	6	90	15	May	18	....	15.0
June 26	2	27¾	13.8	June	122	....	13.6
June 27	5	60½	12.1	July	31	....	12.3
June 29	3	35	11.6	August	15	....	9.4
June 30	1	11¾	11.7				
July 1	11	139	12.6	Total	193	....	12.5

Record of salmon sold from weirs Nos. 161 *and* 162, *south end of Wetmore Island.*—Cont'd.

Date.	Number of salmon.	Aggregate weights.	Average weights.
1871.			
April 17	1	21	21.0
April 20	1	22	22.0
April 30	1	18	18.0
May 13	2	40	20.0
May 15	1	9	9.0
May 16	1	9¾	9.7
May 19	1	20	20.0
May 22	3	29¾	9.9
May 24	2	18¾	9.3
May 26	5	60	12.0
May 27	1	13¾	13.7
May 29	2	30	15.0
May 20	6	72	12.0
June31	1	12	12
June 2	2	24	12.0
June 3	1	10	10.0
June 5	3	37	12.3
June 8	3	38	12.6
June 9	3	40	13.3
June 10	4	67	16.7
June 11	5	63	12.6
June 12	7	82½	11.7
June 14	3	50	16.6
June 15	4	61½	15.3

Date.	Number of salmon.	Aggregate weights.	Average weights.
1871.			
June 17	4	54	13.5
June 19	8	75	9.3
June 20	8	123	15.3
June 22	2	29½	14.7
June 23	5	57	11.4
June 25	2	43¾	21.8
June 26	8	96¼	12.0
June 28	2	24	12.0
July 1	2	30	15.0
July 3	1	9	9.0
July 4	2	30	15.0
July 6	2	26	13.0
July 10	3	37	12.5
SUMMARY.			
April	3	....	20.3
May	24	....	12.6
June	75	....	13.1
July	10	....	13.1
Total	112	....	13.2

Date.	Number of salmon.	Aggregate weights.	Average weights.
1872.			
May 1	3	58	19.3
May 6	2	42½	21.2
May 10	1	9½	9.5
May 13	3	62½	20.8
May 20	2	45½	22.7
May 30	5	81	16.2
June 1	1	11¾	11.7
June 4	4	58¾	14.6
June 5	8	94	11.7
June 8	2	23	11.5
June 10	2	20	10.0
June 11	13	155	11.9
June 12	4	59	14.7
June 13	7	75	10.7
June 14	6	81	13.5
June 15	9	131	14.5
June 17	7	113½	16.2
June 18	11	139	12.6
June 19	4	43	10.7
June 20	3	35	11.6
June 21	6	67	11.1
June 22	10	146½	14.6
June 24	10	152	15.2
June 25	2	24	12.0

Date.	Number of salmon.	Aggregate weights.	Average weights.
1872.			
June 26	2	17	8.5
June 27	2	23	11.5
June 28	8	105	13.1
June 29	14	....	....
July 1	9	127½	14.1
July 2	5	52	10.4
July 3	3	31½	10.5
July 4	10	123½	12.3
July 5	6	66½	11.0
July 6	2	36½	18.2
July 8	8	97½	12.1
July 10 to 19	23	279	12.1
July 20	2	28	14.0
SUMMARY.			
May	16	....	18.6
June	135	....	13.0
July	68	....	12.3
Total	219	....	13.2

Record of salmon sold from weirs Nos. 161 *and* 162, *south end of Wetmore Island*—Cont'd.

Date.	Number of salmon.	Aggregate weights.	Average weights.
1873.			
May 1	3	54¼	18.1
May 5	2	39½	19.7
May 8	3	50½	16.8
May 9	1	12½	12.5
May 12	1	9¼	9.2
May 15	2	36½	18.2
May 19	3	49¼	16.4
May 21	3	29½	9.8
May 22	3	51½	17.1
May 26	2	21⅜	10.7
May 27	1	13½	13.5
May 28	4	53¾	13.4
June 2	9	127	14.1
June 5	12	158	13.1
June 7	12	176½	14.7
June 9	3	41	13.6
June 11	9	121	13.4
June 12	8	123	15.3
June 13	6	76	12.6
June 14	8	99	12.1
June 16	16	202	12.6
June 17	11	156	14.1
June 18	9	108¼	12.0
June 19	5	71½	14.3
June 20	7	85	12.1
June 21	38	....	....
June 23	10	144	14.4
June 24	40	....	....
June 25	5	68¼	13.7
June 26	15	203¼	13.5

Date.	Number of salmon.	Aggregate weights.	Average weights.
1873.			
June 27	31	416	13.4
June 28	2	26⅜	13.2
June 30	14	179	12.7
July 1	20	160¼	8.0
July 2	31	402½	12.9
July 3	9	113¾	12.6
July 4	10	123½	12.3
July 7	27	320½	11.8
July 8	15	185	12.3
July 9	6	91½	15.2
July 10	5	....	....
July 13	5	59	11.8
July 15	4	54¼	13.5
July 16	2	32½	16.2
July 17	4	....	....
July 17	6	78	13.0
July 26	3	40	13.3
July 30	3	42½	14.2
July 31	1	17	17.0
SUMMARY.			
May	28	421¾	15.0
June	270	2,581¾	13.4
July	151	1,720¼	12.1
Total	449	4,723¾	10.5

14.—SAINT GEORGE RIVER.

Salmon were plenty in this river fifty years ago, and considerable numbers were caught twenty-five years later. But they gradually ceased to frequent the river, and for the last ten or fifteen years they have rarely been seen in it.* Since the building of the dams that have mainly contributed to the extermination of the salmon, fish-ways have been maintained for alewives, and have answered their purpose passably well, but they do not appear to have met the requirements of salmon.

15.—MEDOMAC RIVER.

This river was originally the breeding ground of the salmon and alewives, but not of shad. Salmon were abundant, more so than in the Saint George. Sixty years ago the inhabitants used to dip them below the lower dam at the head of the tide. More recently, the owner of a mill further up the stream, at the upper dam in Waldoboro' Village, used to catch them by shutting his gate and taking as many as a dozen at a time from a basin in the rock below the dam, in which they were left by the subsidence of the water. For the past forty years it is be-

* Letter of A. M. Wetherbee.

lieved that not a single salmon has been taken in the river above the flow of the tide, but occasionally, within twenty-five years, one has been caught in a weir nearer the mouth of the river. Three dams at Waldoboro' Village, one at the head of the tide and the other two within a third of a mile of the first, effectually prevent the ascent of all migratory fish.*

16.—SHEEPSCOT RIVER.

This river appears to be well fitted for the production of salmon, and in old times they frequented it in great numbers along with alewives and shad; but, as in other cases, the construction of impassable dams has cut them off from their main breeding-ground, and nearly exterminated them. This happened at an early day. For many years, however, salmon have come in small numbers each year to the dam at Alna. Twelve or fifteen are said to have been caught there in 1872 and 1873—a larger number than usual. Probably they find a very small breeding-ground below the dam.

17.—KENNEBEC RIVER.

In its original condition, this river was the second in the State of Maine in the number of salmon yielded by its fisheries, and in the facilities it afforded for their reproduction. No serious natural impediment exists to their ascent up the main river as far as Carratunk Falls, in the town of Solon. At this point there is a precipitous fall, 16½ feet high, which was a serious hinderance to them, but was not impassable. The whole river falls into a chasm in the ledge less than 60 feet wide and of great depth. Leaping obliquely from this chasm, the salmon would rise into the air to a height of 10 or 12 feet, and strike the body of falling water at a point where its velocity was so small that they could stem it successfully. This was often witnessed, but it is supposed that only salmon of exceptional strength could accomplish the feat. Once above Carratunk Falls, a vast extent of breeding-ground lay open to them in the main Kennebec and its tributaries. Of the lower tributaries, their principal resorts were in the Carrabassett and Sandy Rivers. The Messalonskee was closed by a precipitous fall of 40 feet a few miles above its mouth. The Sebasticook, though an excellent shad and alewife river, was not well fitted for salmon. Tradition says that they ascended the Cobbosseecontee.

In the days of their abundance, the main fisheries for salmon were within 20 miles of the mouth of the river, at Waterville 60 miles above, and at Carratunk Falls. At the latter place, dip-nets were used on the falls and drift-nets just below. It was easy for two men to load a boat with salmon here in a day. At Waterville, just below Ticonic Falls, a large number of drift-nets were plied every season. As many as 82

* Letter of F. M. Everleth.

have been counted at work at one time; but the average was not over 40. They took several thousand salmon in a season. Other drift-net fisheries existed at Augusta and various other points on the river. The fisheries near the mouth of the river were carried on with set-nets and weirs, the former coming into use much earlier than the latter. No exact statistics of their catch have been obtained. The use of nets was not confined to the river. Several were set quite outside its mouth on Hunnewell's Beach. At Cape Small Point, 6 miles west of the river, there were several nets set, and one trap or pound-net is still in use at Bald Head, for the capture of various species, among which salmon are accounted of considerable importance. The salmon-fisheries of the Kennebec were in a flourishing condition in 1873, when the dam at Augusta was completed. For a few years after that they continued plenty, and then rapidly declined until they almost disappeared. The drift-net fishery at Augusta was for some years abandoned because of the scarcity of salmon. The decade from 1850 to 1860 is generally believed to have been the period of greatest scarcity. In 1866, 1867, and 1868 there was a marked increase, the latter year being by far the best since 1850. After that there was another decline, 1870 and 1871 being poor years. In 1872 and 1873 there has been another increase, which far surpasses that of 1868. It was also remarked on the Kennebec as on the Penobscot, that the salmon of 1873 were of an uncommonly large size on the average.

At the present day, salmon are caught in weirs in the lower part of the river and drift-nets at Augusta. The drift-nets, rarely over two or three of them in operation at once, are plied solely for salmon, and, the Augusta dams holding them firmly in check, the number caught in favorable seasons probably amounts to several hundred. The weirs are all below Richmond. They are in general built more for the capture of alewives and shad than for the salmon. Those that yield the most of the salmon are below Merrymeeting Bay; the best of all being near the mouth of the river. The number built below Bath in 1873 was 23, just the same number as in 1867, but a falling off from the next succeeding years; there having been 33 in the same district in 1868, and 26 below Lee's Island in 1869. These weirs are in no essential particular different from those in use in the Penobscot. In Merrymeeting Bay, however, the kind of weir in common use is more like the herring-weir of the eastern part of the State, the fish being captured with a seine in a large pound.

The inquiries made in regard to the number of salmon caught in 1873 elicited the following items of information. One estimate places the number caught below Bath at 700.* From another source† I have a list of the fishermen below Phippsburgh Center, 14 in number, probably

* Thomas E. Scott, of Georgetown.

† D. D. Swazey, of Fort Popham.

building about that number of weirs, and a statement of the catch of each. The sum-total is 645, which would indicate that the preceding estimate was too small. Thirteen of these fishermen caught during the last three years the following numbers of salmon:

	Salmon.
1871	154
1872	237
1873	575

Mr. S. W. Cushing, of Bath, dealer in fish, states that, in his opinion, the catch of salmon in the Kennebec, in 1873, is more than double that of any previous season for fifteen years excepting 1872, and very largely in excess of that year. On the basis of these several statements the following estimate of the catch of 1873 is submitted:

Salmon caught below Bath	900
Salmon caught above Bath	600
Total	1,500

This is believed to be an approximation, though a rough one, to the true number. The yield of 1871, if we may take the experience of the lower part of the river as indicating the true ratio between that and other years, must have been less than 500.

The artificial obstructions to the ascent of salmon as well as other fish are numerous and formidable. There are six dams across the main river below Carratunk Falls. Three of them are formidable obstructions. The dam at Augusta is 18 feet high, and would be absolutely impassable were it not for the lock provided for navigation. Through this a greater or less number of salmon passes each year. Almost every summer a few of them pass the second, third, and fourth dams, and are seen at Skowhegan; and not infrequently they pass this point also. None of the dams are now provided with fish-ways.

18.—ANDROSCOGGIN RIVER.

In the natural adaptation to the growth of salmon, the Androscoggin is supposed to have been scarcely inferior to the Kennebec. In purity of water it is superior, and it has a much greater extent of gravelly river-bottom, swept by brisk currents, where salmon like to lay their eggs. Its disadvantages were its difficult falls. That at Lewiston, though it may have turned back the greater part of the salmon, was, nevertheless, scaled by some that appeared at the foot of East Rumford Falls, where they encountered a series of cataracts quite insurmountable. Direct testimony has been obtained only to the fact of one or two salmon being taken here more than fifty years ago; but tradition has it that they were once very plenty in Swift River, a tributary that enters the Androscoggin just below the falls. They must have been early shut out from that part of the river. At Lewiston they were taken as late as 1815.

Early in the present century the dams at Brunswick shut them out from all their breeding-grounds. Probably the Androscoggin salmon were utterly exterminated; for the few specimens now and then seen in the river are no more then we should expect to stray into it from the Kennebec. These two rivers unite their waters in Merrymeeting Bay, into a broad arm of which each of them flows. In the southwest arm, or that leading to the Androscoggin, are commonly built about six weirs, in which shad and alewives are caught. Sometimes several years have passed without a single salmon being taken by any of them. In 1873 there were four weirs in operation. One of them caught four salmon, another caught one, and two more were taken at the mouth of Cathance River, which point they probably reached without leaving the Androscoggin waters.* A single smolt, six inches long, was caught in the middle of the Androscoggin Bay,† a thing quite unprecedented in the experience of the fishermen of this region. Other specimens, supposed to be smolts, were caught near the falls at Brunswick.

The two lower dams in the Androscoggin, both at Brunswick, have been provided with fish-ways.

19.—ROYALS RIVER.

Salmon frequented this river regularly and in considerable numbers sixty years ago; but they have been shut out by several dams, the first of which is at the head of the tide. The last salmon seen in the river were taken twenty years ago in a weir. There having been no river-fishing there since that time, it is not known whether any salmon have entered the river.‡

20.—PRESUMSCOT RIVER.

This is a river of uncommon purity, draining, as it does, the second lake in size in Maine, and receiving few tributaries below. Salmon, shad, and alewives originally ascended the river. Salmon were practically destroyed by the dam on Presumscot Falls, near the mouth of the river, very early in the present century. That dam was afterward abandoned, and of late years salmon have occasionally been caught. In 1866 four were caught at the Presumscot Falls with a dip-net. In 1873 a weir was maintained in the tidal part of the river, but took no salmon. In October two salmon were seen below the dam at Cumberland Mills, and, the flood-gates being open soon after, they probably passed up, and spawned near Sacarappa. A spent female salmon, of 13 pounds weight, was killed in November at the latter village, and a spent male of 14 pounds above the dam at Cumberland Mills about the same time.§

There is a large number of dams on the Presumscot, but few of them are formidable.

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* Letter of William Rogers.

† Letter of Robert Waid.

‡ Letter of Frank Seabury.

§ Letter of G. W. Hammond.

21.—RICHMOND'S ISLAND.

This island is midway between the Presumscot and Saco Rivers, about three-fourths of a mile from the town of Cape Elizabeth. Between the island and the main-land is a sand-bar at times bare at low water. On the western side of the same for about twenty years a pound, or large fish-net, (a seine,) has been set, extending from the island to the main shore. Every spring and summer each year, a few salmon (from six to twelve) have been taken with other fish, shad, alewives, &c.*

These Richmond Island salmon can hardly be referred to the Presumscot or Saco; for were these rivers to produce salmon enough to afford so many at a point so far distant from their mouths, there would certainly be a larger number found in the rivers themselves. The Kennebec is the nearest river that produces any salmon, and was probably the native river of those caught at Richmond's Island, though this implies a wide range along the coast, the distance being 26 miles.

22.—SACO RIVER.

Salmon used to ascend this river as far as Hiram Falls, and a good many were taken there in old times.

The Great and Little Ossipee Rivers, the principal tributaries, were also frequented by them. The brood has been extinct for many years, and had become much reduced at least eighty years ago.

There are many dams on the river; and those at Saco and Biddeford render the falls at that point, which were always difficult, quite insurmountable.

Since 1860 there have been four salmon taken in the mouth of the river in shad-nets. One of these was caught in 1873.

23.—MOUSAM RIVER.

This small river was once very productive of salmon. The date of their disappearance cannot be fixed exactly, but it was doubtless very early.

A dam was built across the river in Kennebunk in 1675, and since 1720 there has been a dam at that point all the time. Alewives and shad are now caught near the mouth of the river, but no salmon have been seen for many years.

24.—PISCATAQUA RIVER.

Formerly salmon were very abundant in this river, breeding in the Salmon Falls River in preference to other branches, although some of them ran up the Cocheco.

It is over two hundred years since the Salmon Falls and some other branches were obstructed by dams, and some authorities date the falling-

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* Letter of N. Cummings, esq.

off of the supply of salmon as early as 1660. They were, however, by no means exterminated till a more recent date.

As late as 1830 stray salmon have been known to ascend the river up to Salmon Falls dam, and to a lower point within twenty-five years. About thirty years ago a large-sized salmon was caught within a few rods of the dam at the head of tide-water by one Moses Varney. Fishermen near the mouth of the river say that in drawing their seines for other fish they have occasionally taken salmon, but it is not reported that this has occurred recently.

25.—MERRIMACK RIVER.

Salmon originally ascended the Merrimack, and its main branch, the Pemigewassett, 150 miles, branching off into only one tributary, Baker's River, which enters the Pemigewassett at Plymouth.

It is also reported that they frequented the Contoocook in small numbers. They were very abundant before the obstruction of the river. Their extinction was gradual. In 1796 a good deal had been done in the way of dams, but they were either low or were wing-dams. By 1814 there was great falling off as compared with twenty-five years before. By 1830 they were quite scarce. In 1847 the Lawrence dam extinguished them, except a few each year that perhaps straggled from the Maine rivers. This river was the first to receive attention from the commissioners of fisheries first appointed in 1866. In that and the two following years the two dams in Massachusetts, at Lawrence and Lowell, and most of those in New Hampshire, were provided with fish-ways. The greatest difficulty was experienced at Lawrence, where the dam is very high.

In its first form, the fish-way was unsatisfactory. It has since been remodeled, and various kinds of fish ascend it; but the difficulties in the way of getting a sufficient supply of spawn, delayed for some years the re-establishment of a brood of salmon in the river.

26.—PAWTUXET AND PAWCATUCK RIVERS.

The only information received about the former occurrence of salmon in these rivers is obtained from the reports of the Rhode Island commissioners of fisheries, who state that salmon were plenty in them both. Vigorous measures are being taken to restore them, some 70,000 young salmon having already been distributed in their branches and those o the Blackstone.

27.—THAMES RIVER.

Salmon formerly frequented this river and several of its tributaries. On the Shetucket they used to be taken in considerable numbers thirty or forty miles above Greenville, but a dam at the latter place shut them out about thirty-five years ago.* In the Willimantic they were caught

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* Letter of William Story.

until 1822, when a dam was built across the stream, which prevented their coming up. Since then dams have been built across the other tributaries, and finally one across the Thames itself, which completely destroyed the salmon-fishery in the river and its tributaries.*

28.—CONNECTICUT RIVER.

Salmon ascended this river in the last century to a distance of three hundred miles from its mouth,† breeding in its headwaters and in various tributaries, in New Hampshire and Vermont. They were plenty up to 1797. In 1798 the Upper Locks and Canal Company put a dam 16 feet high across, just below the mouth of Miller's River. Within ten or twelve years this extinguished the fish; that is, when all the *then* iving fish had died.‡

The States of New Hampshire, Vermont, Massachusetts, and Connecticut have since 1866 been making joint efforts to restore salmon to the river. Small lots of salmon-fry have, from time to time, been placed in it, and within two years several young salmon have been taken in the lower part of the river. It was not, however, until 1873 that any planting was made on an extensive scale. In the spring of that year there were distributed, by the State of Connecticut, a large number of fry in some of the lower branches of the river. The opposition of the proprietors of the Holyoke dam, in Massachusetts, to the erection of a fish-way, entailed tedious litigation, which delayed the construction of the way until 1873. It is, however, now completed, and the commissioners of the several States interested are to place several hundred thousand salmon-fry in the Connecticut and its tributaries in the spring of 1874.

29.—HAMMONASSETT RIVER.

In this little river, salmon were caught from 1663 to some date in the present century.§

30.—QUINNIPAICK RIVER.

Salmon used to frequent this river, but disappeared at some date not ascertained. In the spring of 1872 a salmon weighing five and a half pounds was caught in a gill-net, set for shad near Wallingford. Another, weighing over four pounds, was caught with a hook in the summer of 1873 by Mr. Stephen P. Northrop, who was fishing for pickerel, with live bait.|| These specimens were probably grilse that came from some of the broods of young fry introduced in recent years.

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* Letter of J. Brown, of Willimantic.

† Letter of Dr. W. W. Fletcher.

‡ Letter of T. Lyman.

§ Letter of William H. Burgis. Hon. William H. Buell, of Connecticut, is authority for the statement of their actual presence.

|| Letter of O. J. Martin, esq.

31.—HOUSATONIC RIVER.

Salmon disappeared from this river many years ago. One correspondent says they disappeared about 1800, and were plenty fifty years earlier, not only in the main Housatonic, but also in the Naugatuck, its largest tributary.* Some four or five years ago there was one of seven or eight pounds caught below the dam at Stratford, and returned by a Mr. Shelton to the river above the dam.†

E—NOTES ON THE GROWTH AND MIGRATIONS OF SALMON

1.—INTRODUCTORY REMARKS.

It is the purpose of this paper to present such facts as have been observed regarding the growth and migration of the anadromous salmon of Maine, adding some facts about the salmon of Canada by way of illustration, no attempt being made to compile from published authorities. This statement will serve to explain the meagerness of the narrative. In fact, the data for a history of the life of a Maine salmon are so exceedingly scanty, that, but for assistance afforded by observations made in other countries, it would be largely an unguessed riddle. This paucity of material is in great part due to the early decline and present scarcity of the species, but, as regards some phases of growth, is believed to be owing to some peculiar conditions, climatic or other, which affect the growth and habits of the fish.

2.—THE NAMES APPLIED TO CERTAIN STAGES OF GROWTH.

The nomenclature of the various stages of salmon-growth in use among sportsmen and naturalists in America is of British origin. Its application to American salmon presupposes an identity of habits in general, and so far as these have been investigated there is nothing to forbid that supposition. As it will be convenient to use several of these imported terms in this paper, their signification requires a word of explanation. "Parr" is the term used to designate a young salmon not yet prepared for its first migration to the sea; its most obvious external characteristics are the dark transverse bars and red spots on the sides. In Scotland this stage lasts for a year in general, and sometimes for two years, and the length of the fish at its completion may be put down roughly at five to eight inches. "Smolt" is the name applied to salmon in the next stage, the commencement of which is marked by the disappearance of the bars and spots of the parr and the assumption of the silvery coat of the adult salmon. The smolt proceeds immediately

* J. W. Webster, of Waterbury; his testimony corroborated by William A. Clarke, of Monroe, and R. S. Peck, of Newtown.

† Letter of P. P. Curtys.

to sea and is seen no more until it returns to the river of its birth, weighing several pounds, say from two to six, when it receives the name of "grilse." It requires another journey to the sea and another season of feeding to produce the adult salmon. After each visit to the rivers for the purpose of spawning, the adult salmon returns to sea in an emaciated condition, when it is termed a "kelt."

3.—THE EGG STAGE.

The eggs of salmon are, in the rivers of Maine, deposited in October and November, in water whose temperature, through the winter and spring, cannot be much above 33° Fahrenheit, and does not rise materially until the snow is melted from the ground and the ice from the lakes. In the interior of the country, about the headwaters of the Penobscot and other large rivers, the ice in the lakes does not disappear until May, and I am confident that the general hatching of salmon-eggs cannot occur earlier.

4.—THE PARR.

Of the infancy of salmon in our rivers very little has been observed. The specimens of parr and smolts that had come into the hands of naturalists previous to last summer may almost be counted on one's fingers. On the Denny's River, when salmon were abundant, a good many parr and smolts (parr 4 to 10 inches long) were caught on hooks by the boys at Dennysville, but, the number of adult fish having declined, the young fell off in a corresponding degree. Young salmon (parr or smolts) have also been taken in Little Falls Stream, in Edmunds, and parr in the East Machias. In Alna, in June, 1869, a parr was taken in the Sheepscot River, and, being confined in a trout-pond, it was, in December following, 6½ inches long, and still retained vermilion spots on the sides, and dark transverse bars only a little less distinct than the spots. In the Penobscot River specimens of parr are occasionally met with. The State commissioners, in the course of a tour of inspection on the upper Penobscot, from July 22 to 28, 1873, found them rising to the fly in almost every pool from the mouth of the Mattagamon to Grand Falls, the upper limit of the ascent of salmon. At Medway, where the Mattagamon joins the Penobscot, they found the people catching them very commonly when fishing for trout.* Mr. Stilwell remarked that they seemed as plenty as he ever knew them on the Miramichi in the course of several seasons of fly-fishing. These fish were about six inches long, and retained the transverse bars and brilliant vermilion spots of the parr.

The salmon-rivers on the west side of the Gulf of Saint Lawrence abound with parr. They take the large salmon-fly intended for the adult to such an extent as to be often a nuisance to the angler.† Mr.

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* Seventh Report of the Commissioners of Fisheries, of the State of Maine, p. 5.

† Statement of Jos. Carr, E. M. Stilwell, W. M. Brackett, and others.

Norris* has observed that in rivers whose salmon are of large size the parr are also large; for instance, that they are much larger in the Grand Cascapediac than in the Nepissiguit. In the Miramichi specimens 6 or 8 inches long can be taken at almost any time during the fishing season.† In the rivers of the Gaspé district they are, in July, about six inches in length, and the smolts, of which a smaller number is caught than of the parr, are a little larger, and commonly retain some faint traces of the parr marks.‡ Some observers failed to find any specimens that had reached the smolt stage.§

5.—THE SMOLT.

Immediately on assuming the smolt coat, the young salmon is believed to go down to sea. In the Penobscot, smolts 6 or 8 inches long are taken in some of the weirs near Bucksport in May or early June, almost every year; but they are so rare that many a man has followed salmon-fishing for a life-time without seeing one. In the Miramichi, Mr. Stone says that he saw thousands of smolts going to sea in July. In Nova Scotia, in the tide-way of Bedford River, near Halifax, five young salmon were taken on the 20th of May, 1865. They were from 6 to 8 inches long, and were perfect miniature salmon in all respects, save a blunt nose and a vermilion spot or two, and some of them had spawn in them.‖ At Eastport, Capt. U. S. Treat takes a number of young salmon in his herring-weir every fall, mainly in September. They are then 6 or 8 inches long. Captain Treat supposes them to come from Denny's River. In the East Machias River, at the head of the tide, young salmon are often taken in dip-nets along with tomcods in December and January. A single specimen that I have seen was a smolt.

From the common occurrence of parr at Dennysville, very near the mouth of the river, and at Bedford bridge, in the tide-way of Bedford River, and from the facts stated about parr and smolts in Canadian rivers, it may be inferred that they reach the sea, in some cases, before the transformation into smolts. This would very naturally occur in short rivers, where all the breeding-grounds lie within a few miles of the sea; and, though it is known that parr have been killed by experimental immersion in salt water,¶ there is nothing to forbid the supposition that the internal change which prepares the fish for life in the sea may precede the external change by which its new condition is recognized.

The facts stated above are quite insufficient to establish the period of the young salmon's stay in fresh water, but it is perhaps admissible to point out their tendency. It seems that those of different rivers do not

* T. Norris, letter.

† Statement of Jos. Carr, esq.

‡ Statement of W. M. Brackett.

§ Letter of T. Norris.

‖ Dr. J. B. Gilpin, letter.

¶ Bertram's Harvest of the Sea, p. 195.

all reach the sea at the same time. In some cases, as at Eastport, they arrive in September, and if these specimens came from the Denny's they may have left it in the summer. In the East Machias they are seen at the head of tide-water in the winter, and they reach the mouth of the Penobscot in the spring. In the latter river the parr observed on its upper waters in considerable numbers late in July were uniformly about six inches long, (this is only an estimate made from memory by the observers,) and can hardly have been less than fourteen months old, and it is quite reasonable to suppose that they should make their appearance at the mouth of the river the next spring, about two years from the time they hatched. But this theory cannot be confidently advanced on the strength of the disconnected phenomena thus far observed.

6.—THE GRILSE.

In the next stage of growth, that of grilse, there appears to be a marked difference between the habits of our salmon and those of more northern salmon. In the rivers of Canada, in general, grilse occur in great numbers, coming in from sea at a later date than the adults, but ascending like them to the upper waters, mingling freely with them, rising to the same fly, and caught in the same weirs. The mesh of the nets is limited by law to a minimum size of 5 inches *in extenso*, and this being too small to hold grilse few of the latter are taken in the nets. To this circumstance it is in part owing that by the time the fish have reached those portions of the rivers suitable for angling, there is commonly, if it be late enough in the season, a great preponderence of grilse, so that more of the latter than of the former are taken by the angler.*

In Nova Scotia † many grilse are taken in the Shubenacadie River, from August to late in the fall. On the Miramichi, in New Brunswick, grilse make their appearance about July 1, and from the middle of that month till the end of August they constitute the main body of the salmon entering the river. Their weight is on the average about three pounds.‡

Some sportsmen report the grilse caught to exceed the adults in the ratio of five to one.§ In the month of August in the Nepissiguit, Restigouche, and Saint John, of Gaspé, grilse exceed the adults in the ratio of three to one.|| They run into the Nepissiguit mostly between July 25 and September 1. Their scarcity during the early part of the angling season, or say previous to July 20, is attested by numerous fishing scores.¶ A series of scores of salmon-fishing in the Godbout River, on the north shore of the Saint Lawrence, shows that previous to July 15

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* Letter of W. H. Venning, esq.

† Letter of Dr. J. B. Gilpin.

‡ Statement of E. M. Stilwell.

§ Statement of N. Cummings, esq

|| Statement of W. M. Brackett.

¶ Mr. Norris found no grilse "in the angling season" in the Restigouche and Grand Cascapediac, but at what date he closed his fishing I do not know.

or 20 the adult salmon taken with the fly in that river exceed the grilse in the ratio of 10 to 1, or more.

In our rivers grilse are seldom seen. Three or four per year is the number caught in a weir in the Saint Croix, which takes about 70 adults.* In the Denny's the ration of grilse to salmon caught is not more than one to 500.† In the Penobscot they are quite as rare, many a man having grown old in the salmon-fishery without seeing a single specimen.‡ Adult salmon running in this river several weeks earlier than in those of Eastern New Brunswick, we should naturally expect the advent of grilse early in July in considerable numbers; but some of the weirs are often kept in operation until the middle or last of July, and sometimes even through August, when they take menhaden; but no grilse enter them. During the latter part of the summer the water at the several falls between Bangor and Oldtown is generally at a low stage, and the attempt of grilse, even in small numbers, to ascend the river, could hardly fail to be frequently detected. A similar state of things exists in the Kennebec. There is no escaping the conclusion that the great run of grilse, which is so prominent a feature in the history of the salmon of the northern rivers, is almost entirely wanting in the rivers of the United States.§ It by no means follows from this that our salmon do not pass through the same phases of growth, or that the growth is more rapid; but merely that when in the grilse stage they generally lack the instinct that impels their more northern relatives to seek fresh water.

Of the characteristics of grilse, as ascertained in the rivers they frequent, it will be sufficient to say that they exhibit to a great degree the characteristics of the adult; that the main external differences are, a shorter head, slenderer form, and a difference in the color and markings; that they are remarkably active and agile, leaping to great heights; that the male is sexually well developed and mates with the adult, but that the female is immature; and that, like the adult, they abstain from food and consequently lose flesh during their stay in fresh water.

Of the length of the interval between grilse-hood and maturity our rivers afford no data for an estimate; and we must therefore be content with the supposition that it is nearly the same as in the case of Scottish salmon, and that this year's grilse is next year's adult salmon. If we also accept the Scottish conclusions as to the rate of growth of parr and smolts, we must assign to the growth from the egg to maturity, a period of two or three years. This must, however, await further observations.

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* Letter of L. Wilson.

† Letter of B. Lincoln, esq.

‡ One old fisherman says that at Veagie he has caught, in a dip-net, salmon only a foot long, with hooks on their jaws. Such instances are certainly rare.

§ Dr. Gilpin has called my attention to the statement by Couch in "British Fishes," that grilse do not frequent the rivers of Cornwall or, for the most part, those of Devon.

7.—THE ADULT SALMON.

(7 *a.*) *The size of the salmon.*—We come now to the adult fish, which is the only form known to most of our fishermen. When in prime condition, they range in weight from 6 or 7 pounds upward. In the Penobscot and Kennebec, and I think in other Maine rivers, this minimum is rarely met with. In the Penobscot very few weigh less than 9 pounds, and the most common size is from 10 to 12. The maximum cannot be definitely fixed. Salmon of 30 pounds are rare, not one out of a thousand weighing so much; but occasionly one of 40 pounds or more is caught. In different rivers there is a variation in size. Those of the Grand Cascapediac, in Canada, are believed to be the largest of their species in America. Those of the Restigouche are large, those of the Miramichi smaller, and those of the Nepissiguit smaller still. In the Clearwater, a small tributary of the Miramichi, they never exceed 6 or 8 pounds.*

(7 *b.*) *The migration up the rivers.*—Salmon ascend the rivers of Maine in April, May, June, July, and August. Arranged according to the comparative abundance of salmon in them, these months would stand thus, viz: June, July, May, April, August; but perhaps in some cases May and July will change places. A great majority, perhaps two-thirds of the salmon, enter the rivers in June. Outside of the five months mentioned there are very few salmon ascending, but, judging from the specimens caught, it seems pretty certain that salmon in prime condition are running in from the sea every month in the year. They have been taken in a gill-net set for them at Buck's Ledge, near Orrington, and the smelt-nets at Bucksport and Winterport take now and then some prime salmon, together with some kelts, in January and February. Off the coast of Nova Scotia, Dr. Gilpin has remarked that there is a large catch of prime salmon in November.

All the adult salmon that enter our rivers in early summer yield mature eggs and milt in the ensuing fall. Nearly 700 specimens caught in June and early July and kept at Bucksport for breeding until fall afforded not a single exception to this rule. The salmon taken outside the rivers in the summer appear to be in the same condition as those in the rivers, and are probably bound on the same errand. The examination of a single specimen, caught at Western Pond Island, the outside limit of the salmon-fishing on the east side of Penobscot Bay, disclosed the existence of spawn in the same stage of developments as in the salmon taken in the river; and it is a well-known fact that the salmon caught in either bay or river have empty stomachs, a sufficient proof that they have left their feeding-grounds, and ground for the conclusion that they are all on their way to the breeding-grounds.

As a general rule, the early migratory salmon are the largest. An average for the several months, from April to July, at least, shows a

* Statement of E. M. Stilwell.

steady depreciation in size. There are comparatively few salmon of ten to thirteen pounds weight caught in April and early May; but this is the ruling size of those coming late in June and in July, constituting what are called the "school-salmon," from their apparent tendency to move in considerable bodies.

Of the sexes, there appears to be a greater proportion of females in the early part than in the late part of the season; but the similarity of the sexes among the early salmon is so great as to generally prevent their separation by external characteristics. By the end of June the males have assumed so much of the peculiar characteristics that mark them at the breeding-season that the sexes can be distinguished with tolerable certainty. In the month of June the females are, in the Penobscot River, largely in excess of the males.

In approaching the rivers, salmon swim near the surface, and are not inclined to leap into the air. In the early part of the season they appear to move at a greater distance from the shores than they do afterward, so that they frequently pass all the pounds and weirs of the estuaries and are first taken in the rivers, where the contracted breadth of the water or some other cause induces them to run near shore. At the height of the salmon season, however, they appear to be coasting along very near the shore, so that where two weirs are built on the same hedge that near shore takes more salmon than the other.

It seems that the main body of the salmon proceeds at once to the vicinity of the spawning-ground. In general, this may be said to be on the headwaters of the large rivers, but in the middle course of such as the Denny's. The earliest reach the limits of their upward migration on the Penobscot before mid-summer.

(7 c.) *Changes in the appearance of salmon while in fresh water.*—From that time until the spawning-season, they lie in deep, quiet pools, and frequently, no doubt, in the lakes traversed by the rivers. Meanwhile, a complete change takes place in their appearance. Both sexes lose the brightness of their silvery sides. The female becomes dark-colored, tinged to a slight extent with some shade of red or orange, and with irregular spots of the same color. All parts of the body fall away in flesh, except the abdomen, and that becomes distended with the growing spawn. The change in the males is more marked. They become very thin from side to side, so that the widest part is near the gills. At the same time their depth increases, and the head lengthens. The jaws become curved, and the lower one is tipped by a large hook that shuts into a cavity in the roof of the mouth; sometimes, indeed making itself a hole quite through the upper jaw, and projecting above The curvature of the jaws is so great that they do not close except a the tips. The fins become very thick and fleshy, the adipose dorsa greatly enlarged, and the whole body covered by a thick mucous coat

that almost conceals the scales. In color the males differ greatly both from each other, and from their own condition in early summer. Some are very light and some very dark. All are curiously mottled on the back with brown, green, or blue, and some shade of red. On the sides are groups of angular red spots, generally vermilion, but sometimes approaching scarlet. The whole lower part of the body is generally suffused with a tinge of vermilion or salmon-red, with occasionally a tendency to purple. The toughening of the fins and the growth of the mucous coating occurs also with the female, but to a less extent. This is their external condition when the spawning-season arrives.

(7 *d.*) *Habits of salmon during the spawning-season.*—In the Penobscot spawning appears to begin during the last week in October. Such, at least, is known from direct observation to have been the time in 1870, in the Mattagamon. In the Miramichi the season is earlier, commencing about the middle of October.* Its progress, if the stage of the water is favorable, is very rapid. In the Miramichi, in 1868, Mr. Stone found most of the salmon had spawned by October 20. Judging from what I saw on the Mattagamon, and during three seasons of artificial spawning at and near Bucksport, I should say that very few salmon would wait until after the 10th of November. But a good deal depends on the stage of the water. If the water is low the salmon will often wait till rains raise it. A female salmon can retain her eggs for three weeks after they are ready to be laid, with little or no injury to them.

The place generally selected for a spawning-bed is just above the verge of a rapid. Frequently, nay, commonly, there is a pool just above t, where the salmon can lie during the day-time. From the behavior of salmon at Bucksport, I should say that, at the spawning-season, they would run down quite as soon as up, to find a suitable place to deposit their spawn, and that they would never perform the operation by day, unless on a dark, cloudy day. Having never observed a salmon of this species in the act of depositing the eggs, † I can only describe the appearance of the nest after it is made. It is a simple excavation, two or three feet in diameter and rarely over a foot deep, with the material that came from it piled by the swift current in a heap below.

(7 *e.*) *Habits of salmon at the end of the spawning-season.*—Having finished spawning, part of the salmon probably drop immediately down river to the sea, and it is certain that part linger in the rivers until spring and descend then. In the weirs on the Penobscot a few of these descending salmon are every year caught, generally early in May. Of

* L. Stone, p. 216 of this report.

† A fresh-water Schoodic salmon excavates the nest by turning on the side and flopping violently against the bottom with the tail. The female alone does the work, the male lying near her, driving off rivals and predacious fishes, and now and then taking his place for a moment close by her side.

the salmon placed in the pond at Bucksport and not caught out again in the fall, many staid of their own accord through the winter in the pond, and only left on occasions of floods in the spring. In the rivers of Nova Scotia the same phenomenon is observed.*

(7 *f.*) *The kelt.*—The salmon seen on their return to the sea are always in miserable condition, thin, black, and weak, and poorer than at the completion of the act of spawning. The fish kept over winter in the pond at Bucksport lost in weight meanwhile, but had regained, to a great degree, the bright, silvery color of the fresh-run fish.

(7 *g.*) *Habits of salmon after leaving fresh water.*—Of the movements of the salmon after this there is as little known as there is of their movements during the growth from smolt to grilse, and from grilse to adult. It can be safely said that they are feeding; but of the location of their feeding-grounds and of the nature of their food scarce anything is known. At their disappearance and at their re-appearance their stomachs are alike empty of food, except in rare instances. At Eastport, Captain Treat has found herring as long as five inches, in the stomachs of salmon, and on the Penobscot some old fishermen tell of having occasionally found their stomachs full of "shrimps," by which term they doubtless mean some small crustacean. They are also known to occasionally bite at the baits on cod and hake hooks on soundings.

The length of their stay in the sea between the visits to the rivers is a matter of entire uncertainty; though it would hardly seem possible for the emaciated kelts that descend in the spring to recover condition soon enough to return the same year to the rivers. As some hundreds of specimens have been marked and dismissed in good health, as detailed in the narrative of the work at Bucksport, it is confidently anticipated that some of them will be taken on their return, and afford data for an estimate of the length of their stay in the sea, and of the rate of growth meanwhile.

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* Letter of Dr. J. B. Gilpin.

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X.—ON THE SALMON OF MAINE.

By A. C. Hamlin, M. D.

1.—THE LAND-LOCKED SALMON.

[Note.—As containing some interesting information respecting the *Salmonidæ* of Maine, especially the so-called "Land-locked salmon," I reproduce, by permission, the following article from Lippincott's Magazine for May, 1869.—S. F. Baird.]

SALMON-FISHING IN MAINE.

A century ago the rivers and lakes of Maine teemed with the salmon and the trout. Not only were the great rivers and expanded lakes frequented by these valuable fish, but even the lesser streams that emptied directly into the sea or its fiords, and the most distant tributaries that drained the wild forests and mountain-ranges of the interior, were stocked with incredible numbers of the *Salmonidæ*. Since this time a great change has taken place; and while casting our fly to-day in our exhausted streams, we can hardly believe the stories of our octogenarian fishermen relative to the vast shoals of fish they encountered when boys, or the still earlier accounts of the Jesuit fathers when they visited our primitive forests and attempted to found "La Nouvelle France."

This almost complete extinction of the noblest of fishes in this State is not the result of the workings of natural law, but due entirely to causes within the control of man. The torch, the spear, the seine, the barrier-dam of the lumbermen, and the choking sawdust of their mills have produced disastrous effects; and, in consequence, but few of our largest rivers contain now any salmon at all, and most of our lakes and mountain-tarns have been despoiled of their trout. We may justly add to the above causes the introduction of the voracious pickerel—

"Tyrant of the watery plain."

The area in this State originally occupied by this miniature shark was very limited, and we even have doubts whether it was to be found anywhere in Maine prior to the year 1700. Its appearance in the Kennebec and Penobscot waters is a matter of recent history, and its ravages among our other fish have been well observed.

The migratory salmon enters now but few of our largest rivers; it ascends them in spring, and passes the summer and autumn season like its prototype, the *Salmo salar* of Europe; but it seems to differ from its European brother in game qualities, for it generally refuses to take the bright, gaudy flies and the silver-sided minnows which are so success-

ful in the hands of the British angler in the rivers of England, Scotland, and Ireland. There is no reason, so far as I know, why our fish should refuse the bait so tempting to his foreign brethren. Although disturbed at the mouths of the rivers by the fishermen with their weirs and seines, and harassed and injured by the floating sawdust in the current of the streams for a long distance, yet it finds deep, silent pools in the upper tributaries, which flow through the primeval forests, where the steps of men are seldom heard. And here, in the very depths of the forests and among the wildest glens, we might expect that success would attend the efforts of the skillful angler, but history records but few instances of it. I remember a party of European sportsmen, who fished twenty-five years ago in the undisturbed pools of the Aroostook River, catching but one salmon. I have seen the fish leap high into the bright sunshine after the natural flies as they played near the surface of the water on a summer evening, and yet refuse the golden-hued artificial insects of the angler.

Why the salmon should be so sullen, wary, or capricious I am at loss to comprehend; still, I am willing to admit that it is possible that in other seasons it might take the bait with great readiness. A part of this singular wariness may be due to the injurious effect of sawdust in obstructing the respiration of the fish; for we know that Sir Humphrey Davy could catch no salmon in the rivers of Norway, whose waters were disturbed by mills and laden with sawdust, yet he was eminently successful in Sweden, where the rivers were clear and unobstructed. On the Seine, the Loire, and other great rivers of France, the anglers cannot raise the salmon with their flies or minnows until they have reached the head-water streams, and all attempts at Paris and Nantes have failed. This circumstance should encourage our fishermen to persevere in their efforts and seek the fountain-streams of our salmon-rivers.

But if we cannot boast of our success with the sea-salmon, we may truly exult over the game qualities of the mysterious fresh-water salmon, which inhabits five of our lake-systems, and which affords as fine sport as the best fish of the Tweed or the Shannon. This fish is less known to anglers than to naturalists, since the latter have quarreled over its classification and made known to themselves the range of its habitat. But the naturalists have been very careful not to express themselves on paper, and hence the sporting fraternity have not been able to glean much from the scientific reports concerning the disputed fish.

Nearly twenty years ago I learned from the hunters that the great lakes which supplied the Saint Croix River abounded with little salmon, whose boldness and activity delighted the few sportsmen who had ventured to penetrate the lonely forests in which the fishing-places were situated. A wild and extensive district of forest-land surrounded the tributaries and lakes of the western branch of this river, and was uninhabited save by a portion of the Passamaquoddy tribe of Indians. This

great tract of forest embraced many thousand acres of land, and presented an extent of country about forty miles in its greatest length by twenty to thirty in breadth. More than twenty lakes appeared in this vast expanse of forest-land, and their tributaries and connected streams meandered or rippled through every part. At the period above mentioned the country exhibited all the wild freshness and sublimity of its primeval beauty; the forest abounded with noble game, and the clear lakes and the limpid and sparkling streams teemed with fine fish. It was in reality one of the wildest parts of the State, and comparatively unknown, except to the hunters, or to the venturesome lumbermen who penetrated into the deepest recesses of our distant forests in search of the pine and the spruce.

The glowing accounts which the hunters gave of the fish and the fishing in these regions were too exciting to be overlooked by a lover of angling, and I resolved to devote the next college-vacation to examining these unknown waters and their precious finny tribes. Therefore, the next September found me on the road which leads from Calais on our eastern frontier to the outlet of the chain of lakes in question, and which was about twenty miles distant. At the outlet I was to engage an Indian guide, and pass up the lakes, by means of a canoe, to the nearest fishing-grounds, which were fifteen miles farther up the lakes. On arriving at the lower lake I encamped at the humble and solitary inn, which serves as a refuge in spring to the returning lumbermen, and at other times to the benighted settlers on their way to new homes in the upper valleys of the Saint John. The worthy landlord corroborated the stories of the hunters in relation to the fish, and sent up to the Indian town for Toma, whom he regarded as the best hunter and fisherman in the tribe. The Indian soon appeared, and engaged to carry me in his canoe to the stream which empties from Grand Lake into the smaller lakes below. We arrived at the month of the stream the next morning, and, disembarking, we hid our canoe in a distant clump of alders, and shouldering our pack, started on the old Indian trail which led to the outlet of Grand Lake, nearly three miles distant. The stream, as it flowed from the lake, rushed with considerable swiftness over the remains of a decayed log-dam, and subsided a short distance below into broad, deep pools. The bed of the stream was of decomposed quartz, and heightened the clearness of the water, whose pure tints reminded me of the Rhone as it flows from Lake Leman. Tall pines cast broad shadows across the bubbling waters, and sharp ledges of rock here and there stretched across the stream and changed the clear currents into foaming cascades. Taken all in all, it was the *beau-ideal* of the angler as a trout or salmon stream.

Laying aside our packs, we soon arranged our camp by stretching a rubber blanket over poles stuck in the ground, and then collecting a pile of fire-wood to cook our food and warn the wolves away at night. While the Indian was building the fire I adjusted my rod, and attached

to the line a gaudy red fly. Creeping out on the end of a log which overlooked a deep eddy below the outlet, I cast the artificial insect out among the bright bubbles dancing gayly down the current. As the fly was descending in the air I had misgivings as to success, for no signs of life were visible in the crystal depths; but the moment it struck upon the surface a dozen silvery forms shot upward to seize it. A strong pull upon the line, and the hum of my reel made my heart leap for joy. Across the stream the little salmon dashed and leaped his length into the air, shaking his head like a terrier in his efforts to free himself from the fatal hook. Down the stream he rushed, and again sprang into the bright sunshine, appearing like a bar of polished silver, so white and lustrous were his sides. Another unsuccessful rush, and he plunged sullenly to the bottom, but my tackle was too strong for him, and I steadily reeled him in, and soon laid him safely on the shore. A more beautiful fish I think I never saw—at least so harmonious a combination of color and symmetry.

"Bring him up here," called out the Indian; "me cook him." Toma took the fish to the spring, split it through the back, sprinkled it with salt, then laid it on a shield woven of alder twigs and exposed it to the heat of the fire which he had just kindled. A little piece of pork stuck on the end of a stick, and suspended over the broiling fish, kept it constantly moistened with its droppings of fat. In a few moments the fish was cooked, and a more delicious morsel never went down a hungry throat; really, at the time, I believed it superior to the salmon fresh from the depths of the sea; but something must be allowed to the success and enthusiasm of the moment, and the exhilaration produced by the balmy air of the forests and the delightful scenery around me.

"Now me show you how to catch fish," said the Indian, as he gulped down his portion of the broiled salmon. "Fish know me." Toma then pulled out from his hunting-bag a long and jointed salmon-rod, with reel and stout line, and some large flies which he had rudely made of the gorgeous feathers of the humming-bird, the red-headed wood-pecker, the blue jay, and others of the gayly-plumed birds of our forests. Climbing to the top of one of the old, decayed piers of the dilapidated dam, which commanded a wide extent of the stream below, the Indian swung out his gaudy fly in the westerly breeze, and made a cast that would have delighted that prince of salmon-fishers, Sir Humphrey Davy. As the rude insect fell upon the foaming current, it seemed as though fifty little salmon sprang for it, their silver sides glistening in the pure water like flashes of light. The stricken fish sprang out quivering in the bright sunbeams, and made a gallant struggle for his life, but in five minutes more he was laid out lifeless upon the white sand of the shore.

"There," said Toma, as he pointed out the beautiful colors of the dying fish, "that fish brother to salt-water salmon, only he forgot to go to sea, but stay in lake instead."

Yes, I think the Indian is right, for on careful examination I find no deviation from the typical structure of the migrating salmon. One observes the same linear markings, with trivial and transitory differences. The bony structure appears to be identical, and we find in the little fish fifteen rays in the pectoral fin, nine in the ventral, ten in the anal, twelve in the dorsal, nineteen in the caudal, and twelve branchiostegals—the same as in the great salmon of the sea. The formation of the head exhibits no radical difference, and the fish are perfect specimens of grilse. I caught out of the same stream little parr and smoults, perfect fac-similes of the young of the *Salmo salar*.

The most singular fact to be considered in connection with this fish is its weight, which in this lake never exceeds four and a half pounds, while that of the migratory salmon sometimes surpasses even sixty.

As this fish has excited the curiosity of naturalists and caused much discussion, we will consider the question of its identity at length, making actual comparison of it with the migrating sea-salmon.

After cautious dissection and inspection of the fresh-water salmon from the five different systems of lakes in Maine, and after many comparisons with the migratory salmon, I have arrived at the opinion that it is identical with the sea-salmon known as the *Salmo salar*, and that radically there is no difference between them, save in the habit of visiting the sea. Some may ask, Why should there be a departure from nature's laws, and how is this variety in particular preserved, when the slightest deviation from the regulations of nature often causes the death of the animal? Others will exclaim, Why have not other varieties arisen from the effect of similar circumstances? In reply I will say that we observe great flexibility in nature's stern rules under the molding influences of man; and it is shown that certain effects of strange food, differing localities and temperatures, may give rise to slight deviations in form, color, and habits, without altering decidedly the characteristics of the animal.

The localities of some of the *Salmonidæ* are strangely circumscribed, and their geographical area or habitat may be very limited. The *Salmo hucho* is caught only in the streams that empty into the Danube. We do not believe, with Pallas, that it occurs in the rivers of Siberia, or that it may be found in those which empty into the Caspian Sea. In the Tweed, the *Salmo eriox*, or bull-trout, is caught as frequently as the salmon, and in the two rivers south of the Tweed there are fifty bull-trout to every salmon; but in the Forth and Tay, which flow into the sea farther north, the species is almost a stranger. The *Salmo toma*, or togue, is strangely distributed in this State; for instance, it is not found in Sebec Lake, but abounds in most of the little ponds which are tributary, and which are also stocked with salmon. In Reed's Lake it is not found, although large ones are taken in its tributary, Philip's Pond, a mile distant. There are other examples in the State, but I am at a loss to explain this singularity in the distribution of the fish in question.

The gillaroo-trout is found only in the lakes of Ireland, and differs very little from the common trout in general appearance, except that it has more red spots and a yellow belly and fins, and is a little broader and thicker; but internally it has a different organization, possessing a large, thick, muscular stomach, which generally contains a quantity of shell-fish. The common trout of the same lakes is not altered in the structure of its digestive organs, and shell-fish are never found in its stomach. The goldie is said to be found only in Loch Eck in Scotland.

So far as habitat is concerned, there can be no objection to the fresh-water salmon of Maine being considered a distinct variety of the sea-salmon. In placing these salmon side by side, we do not observe any great difference of form that may not be explained as the effect of food and locality. Age and increased size make a marked difference in the appearance of the head and opercular apparatus, as may be seen by comparing a number of salmon of different ages and weights. The scales of the pectoral region in the small fresh-water salmon are decidedly ellipsoid, but in the full-grown sea-salmon they are quite circular. Shall we adopt this as characteristic? By no means, for we can find the elliptical scales in the young salmon, and explain the difference by the growth. If we take a number of salmon from different rivers, we will find differences in their general appearance, but not enough to justify an attempt at a new classification.

It is thus shown that forms may vary slightly, and that naturalists should not regard mere variations as a mark of distinction. For illustration, we will take the conger-eel of the British waters. If we consider difference of head and color of body, we might believe in the existence of several more species than are now recognized; for we may observe as much variation in the snouts of different individuals of the conger-eel family as there is between the sharp-nosed and the broad-nosed eel. Some specimens in the Edinburgh University Museum show elongated and narrow proportions in the anterior part of the head, but in others the same outlines are comparatively short and blunt.

The colors of fish are very capricious, and often depend upon local and adventitious influences. The coloring matter is not in the scales, but in the surface of the skin immediately beneath them, and is probably a secretion easily affected by the health of the fish, the quality of the water in which it lives, the light to which it is exposed, and the kind of food which it eats. In the dark waters which flow through boggy moors the tints of their finny inhabitants are deep; the light silver hues change to a golden yellow, and into the intermediate shades, even to a dark orange. But in the crystal waters of the purest streams, flowing over pebbly bottoms and white sands of decomposed quartz, the colors of the fish are very pure, and the luster is of such brilliancy as to give the appearance of transparency. We do not only observe this assimilation of color in fish to the places they frequent, but it is the same with the animals of the land. It is one of nature's provisions,

and is required for safety and concealment. Dr. Stark showed many years ago how suddenly the stickleback and other fish changed color when removed from dark pools and placed in white bowls. The change of hue took place with as much rapidity as though it were subject to the caprice of the fish, as is the case with the chameleon.

Food has a very decided influence, and in connection with other circumstances will produce a marked effect in the appearance of *Salmonidæ*, even in the same lake. Thus, in Lake Guarda, in Italy, we may observe one specimen with silver sides, blue back, and small black spots, and another of the same variety with yellow belly, red spots, and an olive-colored back. The like phenomena have been observed with trout of the same variety in the lakes of Germany and Ireland. Differences of food and habits, says Davy, may occasion, in a long course of ages, differences of shape and color, which may be transmitted to offspring. Trout that frequent clear and cold waters, and feed much on larvæ and their cases, are not only red in flesh, but they become golden in hue, and the red spots increase and outnumber the black ones; but when feeding upon little fish they become more silvery in color and the black spots increase. We have some singular examples of the effects of difference of diet. The peculiarity of feeding on shell-fish produced the gillaroo-trout, a remarkable variety found only in the Irish lakes. The charr also is liable to great variations from the effects of its food, and its history has, in consequence, been much confused by the naturalists. We observe similar effects with the *Coregoni*, or white-fishes; for instance, the powan of the Scottish and the pollan of the Irish lakes. Agassiz noticed that pet parrots, when fed upon certain fish of the Amazon, changed colors, and their green plumage became spotted with yellow.

Age also often causes a great difference in the appearance of fish, and the markings of the young change singularly with their growth. The Cornish sucker has two large ocellated spots behind the eye, which are not visible in the young fish.

It is true that there is a marked difference in size between the lake-salmon and the migratory salmon. There is also the fact that the one seeks the sea, while the other does not. But these seeming distinctions may be readily explained by the effects of food and locality. Sir Humphrey Davy, who was an angler for fifty years, believed that differences depending upon food and size will account for the peculiarities of particular fish, without supposing them distinct species. He sometimes caught salmon quite unlike in form, markings, and color, and satisfied himself that these differences were due to disease or to accidental circumstances. Young, in his admirable work on the history of the salmon, gives a remarkable instance of singular differences occurring in a very limited locality: "We know of five rivers which run into the same estuary, and all and each of these rivers have their own peculiar salmon; and the fish differ so much, the one from the other, that they are quite

easily distinguished. The first river has a race of well-shaped salmon whose average weight is about ten pounds. The second has a strong, coarse-scaled, rather long but very hardy salmon, whose average weight is about seventeen pounds. The third river has a middling-shaped salmon, whose average weight is about nine pounds. The fourth river has a long, ill-shaped salmon, averaging about eight pounds; and the fifth river has a very well-shaped salmon, whose average weight is full fourteen pounds." This experienced naturalist adds that it is rare for a salmon returning through the common estuary to miss its way to its own stream.

The difference of proportions in salmon taken from different and even contiguous rivers has often been noticed, and is due to local causes. The proportions between the salmon of the river Bush and the river Bann near the Giant's Causeway differ in the ratio of length to girth as 20 to 9 and 20 to 13.

The differences of color between the lake and migratory salmon are not great, and Agassiz does not regard color as of any importance in relation to specific character. The sea-salmon, when well-fed, has a smaller head, a more rounded body, and a more silvery luster. The small heads and rounded bodies, considered as merely proportional, are easily explained by the influence of food. The colorings of the fish are dependent upon the same cause, as well as upon age, season, and the purity and chemical composition of the water they frequent. For effect of food and locality we have many positive examples among our domestic animals and birds. Thus the lake-salmon may be identical with the migratory salmon, altered in size and disposition after many generations. This principle of change of character and transmission of such character to offspring is well explained by Darwin.

If there is no difference in typical structure, there is, however, a marked discrepancy in the habits of the two fishes, for the one has lost the instinct to visit the sea; and this is a very marked characteristic with the migratory salmon, the young fish sometimes throwing themselves upon the shore in their frantic endeavors to pass the barrier-dams. However, the English naturalists have admitted that it was possible for the parr to lose its instinct for the sea and propagate its species in the rivers, deteriorating greatly in size and quality.

The sea-trout, *Salmo trutta*, can breed and thrive quite well without descending to the sea, but it soon loses its marked characteristics, and resembles the common trout.

All of the systems of lakes where the fresh-water salmon is found were frequented by the sea-salmon up to within a comparatively short period of time, and the dams of the mill-men are now the only barriers to the migration and emigration of the fish. We can readily conceive that the young salmon might remain over one or two seasons in these lakes before visiting the sea, propagating a family which had less desire to visit the salt water; and thus in successive generations a race

might be produced which would lose all instinctive desire to migrate, and adopt the lake instead of the ocean as its habitat.

In reality, these inland waters are as the sea to this fish, for it ascends the tributary rivers to spawn, returning to the lake again, as the *salar* returns to the sea. But if this salmon has sprung from the sea-salmon, why do we not find it in the lakes of England, the lochs of Scotland, and the loughs of Ireland, where the salmon has had unrestricted access from time immemorial?

This certainly is a difficult question to answer with satisfaction, since we find the same variety of salmon in the lakes near Katrineberg in Sweden, where great numbers are captured annually. It is said that it is bred in the lakes there, and cannot have access to the sea on account of cataracts, and that it is small and inferior in flavor. When Lloyd first described it, the British naturalists denied the story, and maintained that the Scandinavian ichthyologists were at fault when they spoke of the fish as identical with the true migrating salmon. It must be admitted that it is somewhat strange that this variety is to be found only in the lakes of Maine and Scandinavia.

The naturalist will ask the question, Has not the lake-salmon appeared since the erection of dams, and, being thus confined and prevented egress to the sea, has it not degenerated into the present variety?

The evidence is very conclusive that this fish existed from the earliest times in all the lakes where it is found to-day, and long before the advent of the European on our coasts. The Indians speak of it in their early traditions. The term "land-locked" as applied to it is inappropriate, since the erection of the dams does not prevent the fish from passing to sea during the spring and winter floods. And the term "dwarfed salmon" is erroneous, since individuals have been caught in Sebago Lake of eighteen to twenty pounds weight, and in Reed's Lake of ten to twelve pounds weight; yet, strange to say, in the great lakes of the Saint Croix it never weighs more than four and a half pounds, and is a little smaller in Sebec Lake.

Here arises a new difficulty: Why should there be such a great discrepancy in the weight of these fish (the smallest coming from the largest lakes) if they are of the same family? In reply, we will ask in return, Why does the migrating salmon of certain rivers average larger than that of others, when there are no physical peculiarities, no difference observed in the respective depth, temperature, or extent of lake-basins to distinguish between them? Small rivers sometimes produce larger fish than rivers of much greater volume and length.

There are some queer exemplifications of this anomaly. Humboldt was astonished to find the crocodiles in Lake Valencia to be very diminutive, while the same species grew to an enormous size in the adjoining rivers. Scarcity of food will prevent the full development of any animal; but this hardly explains the difference in the sea-salmon, for it obtains its weight, after passing the age of the smoult, by feeding

in the sea. The migrating salmon actually loses weight while passing the summer in the rivers, and it does not regain it until it returns to the sea, where it increases in flesh with extraordinary rapidity.

Taking the migratory salmon as the type, we do not observe any differences from it in the structure of the lake-salmon that may not be explained by food and locality. In reality, the differences are trivial, since nature, undisturbed, is rigid in the laws of forms and proportion. But we may judge of their flexibility from the singular effects produced in pisciculture. The Chinese have shown in their fish-culture how man may play with nature and control organic form to a certain extent. The illustrations of the French naturalist, M. de Savigny, show how this singular people have cultivated the gold-fish even to eighty-nine varieties, and how they have secured and seemingly perpetuated certain forms with double fins or destitute of fins, and possessing other singularities; also, how they have succeeded in producing almost every possible combination of metallic tinting—gold and silver, orange, purple, and black. Yet these monstrosities, when left to themselves, soon revert to the original type, like the castaway horses of Sable Island.

The circumstances connected with the birth and growth of the salmon are very interesting, and have given rise to animated discussions among the European ichthyologists.

There are sedentary species of fish which live and die in the same locality, often extremely narrow in its limits; while there are others of migratory disposition, and condemned, like the Wandering Jew of the legend, by irresistible instinct, to move without cessation and without reaching an end to their lifelong journey. These wandering tribes, however, are subject to periodic laws, which direct their migration and emigration.

Of all the fish of passage, the salmon is perhaps the most remarkable. He is certainly the noblest, and ranks the highest among his class in intellectual instinct. The angler justly looks upon him as the prince of the streams; and what can compare with his beautiful proportions, his rapid and graceful motions, his silvery hues, his keen and lively eye, his rich and delicate flavor? The luxurious Romans, who searched distant climes for delicacies, knew nothing of this splendid fish—no more than we know of the gourami of China. The ancient writers are silent concerning it, with the exception of a remark of Pliny, and the inscription in the Mosella of Ausonius: *Purpureisque salar stellatus tergore guttis.*

In the spring and early summer the salmon enters the rivers, and swims up to the cool tributaries with great rapidity. Falls of ten feet in height he surmounts by a single leap, and he stems the swiftest currents with the greatest ease. On arriving in the clear streams which flow from the fountain-heads, his journey is at an end; he selects his mate and waits for the nuptial period of autumn.

Trout pair together in June, and their seeming constancy and affec-

tion for each other indicate something more than mere animal instinct. This fact was observed and celebrated by an Italian author in the "Loves of the Fishes," two hundred years ago.

We will not attempt to say whether the male or female salmon prepares the nuptial couch and digs the trench in the crystal sands. Some maintain that the female fish does all this, while others assert that the male prepares the bed. If the male does not do it, why should his lower jaw become like a hook at this period only? The sturgeon uses his elongated snout to plow up the mud, and why may not the male salmon his hardened jaw in furrowing the sand-beds? Not only does the lower jaw of the salmon change during this time, but his forehead becomes tough and strong.

In ninety days or more, according to the temperature, the eggs hatch—at least those which the hungry eel and trout have left—and the little fish then appear, to run the gauntlet of life from their voracious enemies. So great is the destruction of spawn and loss of infant fish that not more than one in a thousand eggs deposited hatch, nor one in three thousand come to maturity. But when protected by man, as in artificial breeding, more than nine out of every ten eggs hatch and thrive.

When the floods of the following spring have subsided, we observe the young salmon has increased to several inches in length, and is now one of the most beautiful of fishes, with its olive-hued markings on the back and its silver sides stained with crimson spots and decorated with a row of golden dots along the lateral line. Another spring these transcendent hues fade away; the red spots grow dim, the brighter aureoles disappear, and all the lively colors sink into gray. This is the migratory dress, and the fish is ready to commence his long voyage to the ocean, which may be hundreds of miles away. The path may lay across broad lakes, down foaming currents, and over seething cascades, but the little fish pursues his way boldly, and with the certainty of destiny. After a few weeks' sojourn in the sea, another remarkable change takes place both in size and color. The marine influence exercises such an extraordinary effect that the descending smoult of spring of a few ounces weight appears in autumn as the ascending grilse of several pounds weight. This same grilse increases but little, if any, during its sojourn in the fresh water, but on returning again to the sea it grows rapidly, and appears the next spring as an adult salmon of nine to twelve pounds weight.

Thus we have the four stages of the salmon's life: First the parr; then the smoult; afterward the grilse; and in the third year the salmon. These distinctive periods are well marked, and the changes of color and form have led many students of natural history into errors.

The researches of practical men like Young and Shaw first cleared away the obscurity which enveloped the early biography of the salmon. Professed naturalists have made the most ridiculous statements concerning this fish, but we know now that the mysterious parr is the

salmon fry. As the little parr progresses in life, many characteristics are laid aside, and only those which mark the species are retained; the parr-markings, the red spots, and most of the dark ones, especially nearly all of those below the lateral line, vanish. The dentition changes. The adult trout retains only the mesial vomerine teeth in a double row; the salmon loses all the mesial vomerine teeth and retains only those of the chevron.

The *Salmo Gloveri*, described by Girard as frequenting Union River in the State of Maine, is only a parr, and is caught in other rivers where the salmon appears. The samlet may remain several years longer than its usual period at the place of birth when debarred or impeded in its access to the sea, and may spawn and propagate a stunted race, as ill-fed animals are checked in their growth and remain stationary. Nearly all of the *Salmonidæ* breed early in life, and size has no effect upon the faculty of breeding, the essential difference being as to number—a thousand eggs being reckoned to every pound-weight of the fish. The differences in position of fins in the *Gloveri* are trivial compared with those which we witness in the young of many other animals during their period of growth.

About forty years ago fresh-water salmon were caught in great numbers in Sebago Lake. The Indians in earlier times speared them in immense quantities in autumn on the shoals below the outlet; the early colonists caught them by the cartload during the spawning-period, but the thoughtlessness and carelessness of civilization have reduced them so much in number that they are now quite rare. Still, a few may be taken with the minnow as they run up the rivers in spring, or by trolling in the lake, off the rocky shore known as the "Image," which was a famous place of resort years ago. In the autumn they again pass into the rivers, and may then be taken with the fly. Some weighing thirteen and a half pounds have been taken with the minnow. Last summer one was caught of ten pounds weight. Others of much greater weight have been speared at night while in the act of spawning. The spear in the hands of the poacher has contributed more than any other cause to the scarcity of this fish. Two years ago two poachers speared in three nights in Songo River more than half a ton of salmon. No fish, however prolific, can long stand such a drain as this upon its numbers. A little protection and care in artificial breeding would make this lake, with its connecting streams, one of the most delightful places of resort for the angler in the world. Down below the outlet the water of the lake, which is of the purest quality, rushes swiftly down and over primitive ledges, and forms magnificent pools and eddies, which are the favorite resorts of trout and salmon. One bright morning last June found me rod in hand and casting the fly at the locality above mentioned, but it was too early in the season, and the gaudy insects failed to attract even a glance from the lurking fish. I substituted a minnow, and trolled him across the boiling eddies below. A whirl in the foam, a splash of

spray, and a strong tug at the line told the story. The hum of the reel as the line swiftly spun out indicated a large fish. Checking his speed for a moment, I could see his sides of silver and pearl glistening in the distant waters below. Alas for human expectations! The log on which I stood, swayed by the current, caused me to lose my balance for a moment. The line slackened for an instant, and the salmon, relieved of the constant strain, disengaged himself quick as a flash, and was off in a moment to a safe retreat.

My companion, however, was more fortunate, and landed a two-pound fish. The first glance at this fish indicated a distinct variety from the salmon of the Schoodic and other lakes; for its sides were very much spotted, even below the lateral line, and some of the spots were underlaid with deep crimson, which appeared in rich contrast with the black and pearl of the sides; the dorsal fin was also very much checked with large and distinct black spots. It would remind the angler of the *Salmo trutta marina* and the *hucho* trout of Europe, so distinctly marked was the dorsal fin. But the examination of five other specimens at a later day proved that the spots were not constant; for not one of the five exhibited more spots than the fish of the Schoodic, and some of them not so many. The appearance of the dorsal fin was also much changed, and in some fish the spots had quite disappeared, which leads me to believe that the excess of spots is due to food and locality.

Bloch, in his work on the *hucho*, says that all the fins have black spots. Professor Wagner says the same; yet Davy, who angled in the Danube and its tributaries, the Save, Drave, Thur, and Isar, could not catch a single fish with spotted fins. The fish preserved in the collection at Munich have none. We may account for this diversity of statement by supposing that the fish were taken at different seasons and localities. I have observed that the pike, at certain times and in certain waters, becomes yellow, with black spots, and then again changes to gray, with pale-yellow dots. The *Salmo trutta*, when confined to rivers and running waters, gains more spots; it is the same with the *hucho*. Davy saw fish from some of the lakes in Ireland that were mottled in a singular way, and he ascribed it to the nature of the water, to exposure to light, and the kind of food. Similar peculiarities are observed with the trout of Lough Neah, which the Irish call "buddocks" and "dolochans." Trout in the river Boyle, running up to spawn late in October, have no spots, but are colored red and brown, mottled like the tortoise-shell. Hence I am inclined to think that the great number of spots sometimes seen on the Sebago salmon is not a fixed, and should not be regarded as a special, characteristic. I think it very probable that the same peculiarity may be observed at times with the salmon of the other lake-systems.

The most exciting, and by far the most proper, way to catch this splendid fish is by means of the artificial fly; and after a while the sportsman disdains to use any other method.

The lover of the "gentle craft" who has never taken the salmon with an artificial fly cannot boast much of his professional skill, since angling for this magnificent fish is deemed the measure or standard of his capacity, the test of his art, the legitimate object of his loftiest aspiration. No lover of nature will ever justify Dr. Johnson's snarling definition of the angler's profession, the poetic vituperations of Lord Byron, or the exaggerated description of the clever Horace Smith. There is no sport that will compare with scientific angling for exciting the mind and sustaining a joyous hilarity. The enjoyment of the pure air, rambling over green meadows, in the grand old woods, among the rugged mountains, and over the beautiful lakes—all this varied intercourse with nature inspires the mind with happy feelings.

The passion for angling is by no means limited to any class of society. The most eminent poets, painters, philosophers, statesmen, and soldiers have been fond of the art. Trajan loved angling, and Nelson threw the fly with his left hand after the Spaniards had shattered his right arm. Ovid, Boileau, Goldsmith, Rossini, were anglers. Dr. Paley was passionately fond of it, and, in reply to the bishop of Durham, as to when one of his most important works was to be finished, said: "My lord, I shall work steadily at it when the fly-fishing is over." Walter Scott, infinitely susceptible to the beauties of nature, was delighted with angling, and more than one passage in his works betrays his predilection for the sport. Walton has justly styled the gentle art as "the contemplative man's recreation." We do not think that angling should be classed with acts of cruelty, for fish, and all cold-blooded animals, are less sensitive than the warm-blooded aninals, and the act of hooking a fish is probably attended with less pain than we imagine, as the cartilaginous part of the mouth contains no apparent nerves. A trout will often continue to pursue insects after escaping from the hook, though he will shun the artificial ones. The pike will seize the bait even when his mouth is full of broken hooks. Sharks are also remarkably insensible to pain.

When the evening is calm and tranquil after a warm day or a stormy period, then it is the best time to cast the artificial fly. At this hour the fish emerge from the cool places of concealment, where repose has sharpened their appetites, and they pursue with avidity the insects that sport near the surface of the stream, or the little minnows who dare venture from their safe places on the shallows. In the taking of the artificial fly, the trout rarely leaps at it more than once, while the salmon will make several attempts. Certain flys are very deadly on certain rivers, but not on others, even when not far distant. This peculiarity in the *Salmonidæ* is quite remarkable, and evinces either caprice or intellectual instinct.

In Switzerland and Illyria, the native sportsmen fish with the rudest imitations of flies, and on the Shannon the largest salmon are caught with clumsy artificial bugs and flies. Fish are not only deceived by these imitations of insects, but even birds are deluded by the sight. From

the lofty cliffs of some of the Ionian Islands the Greeks capture the swallow on the wing by casting into the air a long line with an artificial fly. Hofland missed his salmon in consequence of a swallow seizing the fly as it was falling toward the pool of water. At times the fish will refuse the tempting morsel, though rising to glance at it, and then dart away as though the deceit was perceived. It is not only evident that fish possess an accute sense of smell, but at times they are very particular as to what they eat; and this daintiness of food has been noticed by very ancient writers.

We believe that the *Salmonidæ* have the sense of smell very acutely developed, for they have ample nostrils, and their structure, and the full and peculiar arrangement of the olfactory nerves, indicate that they possess this power, even if its existence were not established by numerous observations. Almost every angler has seen a fish reject a bait that did not suit his taste, even after he had taken hold of it. The salmon not only measures the objects of his pursuit with his eye, but he smells them while pursuing and tastes them when seized. Many times have I noticed the trout on a summer evening champing the luckless fly that had fallen into the water as though it was a delicious morsel. In trolling artificial minnows, whose artistic make almost surpasses nature in beauty of outline and color, I have been vexed to see a salmon darting around it with seeming disdain, and never attempting to seize it. In such cases, the fish must have been influenced by smell; for the eye could hardly detect the structure of the bait or the concealed hook.

The white shark has very large nostrils, and smells its prey at a great distance. Throw to a voracious pike a toad, and he will turn from it with very marked loathing. Hang a shiny tench under his nose and he will recoil as quickly as the sensitive maiden turns from the nauseous smell of the poppy.

Fish are much affected by external influences, such as inclement weather, &c. "Never angle while the chilly east wind blows," is a world-wide maxim. To illustrate the rapidity with which impressions are transmitted in water, I will give an instance that amused me in boyhood. On throwing a little pebble moistened with spittle into the pool below the dam of Pleasant River, not far from tide-water, I observed that the lamprey-eels sprang out on land as though the water of the pool was molten lead, but returned again in a few moments and became quiet. Large rocks thrown into the water did not disturb them, but a minute pebble covered with spittle threw them into the wildest agony. Forty years ago the lawyers attending court at Machias frequently amused themselves by disturbing in this manner the lamprey-eels as they congregated in the pool below the dam. The human saliva evidently acted as a poison, and its influence was felt instantly in the most distant parts of the pool. There are many other remarkable instances of the susceptibility and the delicate organization of fish. The vendace is said to perish the moment it is touched by the human hand.

As I have said before, the salmon occurs in five of our lake-systems. Although there are other lakes advantageously situated near the coast, and much frequented in former times by salmon, yet they do not contain the new variety, if variety we dare to term it. This singularity in its distribution is another remarkable feature to be considered in its study.

Early in the month of May the fish in question passes into the inlets and outlets in search of the smelts who have gone there to spawn. Here it remains a few days, and then returns with the smelts to the lakes. In June it again returns for a few days to the foaming currents of the swift streams to enjoy the aerated water and rid itself of the parasites which infest the still waters; for even fishes are troubled with parasites. Sometimes they appear as little leeches, and stick to the gills of the fish; and then again we find them in other forms, and attached to other parts of the body—in the eye, for instance, as is the case with the shark. They also become diseased like land-animals, which fact did not escape the notice of Aristotle two thousand years ago. One of my prizes from Sebago Lake had a cataract in its left eye.

In September the salmon again seeks the clear streams, where it remains until the spawning-period is past, or until November. In May it prefers for bait the minnow or smelt, but in June and autumn it will readily take the fly, preferring the bright and the gaudy.

We know of no places in America where the angler can be more gratified with a fishing-rod in hand than among these lakes.* If he be skillful in casting the fly or trolling the minnow, he will be charmed and astonished with his success in the great Schoodic Lakes, either in the Chepeteneck or the Witteguerguagum. And at the same time, if he be a lover of nature, he will find wild and lonely scenery, yet full of grandeur and picturesque beauty, and all that is calculated to make a deep impression upon the feelings and awaken the contemplative and reflective powers.

BANGOR, ME., *September* 11, 1872.

DEAR PROFESSOR: Yours of the 4th is at hand. The number of Lippincott's Magazine containing my article on the salmon is May, 1869.

Since I wrote this article, I have satisfied myself that the non-migratory salmon have been seen in the Schoodic, Penobscot, and Union River waters only since forty years. Concerning the Sebago salmon, I am not so positive, but am quite sure the variety is not one hundred years old, or since the erection of impassable dams on its outlet. The Schoodic salmon are about forty years old, and the old Indian hunters have given me the precise time of their appearance and the disappearance of the migratory salmon, which coincides with the erection of impassable dams.

* The Sebago, Sebec, Reed's, and the lakes of the two branches of the Saint Croix.

Migratory salmon of large size were at that time speared on the same grounds where the small salmon are now taken in great numbers, and which are never over five pounds in weight.

I have published but one other paper on the *Salmonidæ*, that on the togue, which is printed in the Maine Geological Reports of Hitchcock's Survey, and I have no doubt but that the description is correct, and the fish new to the scientific world.

The *Salmo Gloveri* is nothing but a parr. I examined the fish several years before Girard saw his specimen, and recognized it as the young of the migratory salmon.

They have disappeared from Union River since the extinction of the salmon.

Yours, truly,

A. C. HAMLIN.

2.—*THE TOGUE.

Salmo toma, Hamlin.

This trout, known among the aborigines as the *togue*, *tuladi*, &c., has been classed by some observers as identical with the *Salmo hucho* of the Danube and of the lakes of Northern Europe; but in these classifications peculiarities of anatomical structure have been overlooked, and the habits of the two fishes have also been noted as similar, whereas in reality they present great contrasts; for the one, agile and alert, seeks the swift and foaming currents of the clearest streams; and the other, sly and sluggish, haunts always the quiet waters of the deepest lakes. It is mentioned by Mr. Gesner in his report upon New Brunswick, and identified with the *Salmo lacustris* of Lake Geneva; a proper examination of the two fishes, however, will satisfy the naturalists that few positive analogies can be drawn; and, again, it is identified with the *Salmo ferox* of Loch Awe, in Scotland, in the descriptive catalogue of fishes of New Brunswick, by Mr. Perley, who identifies from the characters drawn by Sir W. Jardine and Mr. Yarrell, some of which would certainly lead the observer, unless minute, into the same error; for it cannot be denied that great similarities are to be observed, but there are also as many with the *S. erythrinus* of Siberia.

In shape it is not so elegant as that of some other species of the *Salmonidæ*, but its whole form indicates great strength and swiftness, although it has the reputation of being slow and sluggish. The female is more perfect in its proportions than the male, not having that gibbous appearance at the nape, where the outlines of the head pass into those of the back, and, besides, its general contour is more delicate.

A rich, pearly luster covers the ventral regions, deepening into russet

*From the Second Annual Report of the Natural History and Geology of the State of Maine, 1862, (pub. 1863.) Article on the Togue, by A. C. Hamlin, M. D.

toward the lateral line, above which the color appears of a deep, mottled gray, still deepening into blue as it approaches the dorsal summit. The same pearly hues, blended and intermingled with gray, are observed upon the opercula. Spots and markings of a light sienna color appear on the sides; these spots are circular without being ocellate, and appear indistinct and grayish upon the dorsal and upon the commencement of the caudal. All these colors vary according to the seasons and local influences, being brighter at the spawning-period than at other times.

Its proportions are quite harmonious. The following are the measurements of a small specimen:

Entire length		18 inches.
Greatest depth		$3\frac{7}{8}$ inches.
Head	length, $2\frac{7}{8}$, with operculum,	$4\frac{1}{2}$ inches.
Pectoral	length, $2\frac{7}{8}$	
Ventral	length, $2\frac{1}{8}$	
Anal	length, $2\frac{1}{4}$, in width,	$4\frac{1}{4}$ inches.
Caudal	length, $3\frac{1}{4}$, in width,	$1\frac{1}{8}$ inches.
Dorsal	length, $2\frac{1}{2}$, in width,	2 inches.

Br. 12; P. 12–13; V. 9; A. 11–12; D. 13; C. 19.
Cæcal appendages, 113; Ver. 65.

Scales are small and elliptical. They decrease in size as they approach the thoracic arch. There are 53 in a vertical row anterior to the entrals, of which 24 are above the lateral line.

The lateral line arises from the height of the upper third of the operculum, curves slightly downward, and proceeds with a slight inflection to its caudal insertion. The pectorals are not proportionally so long as those of the *siscowet*, and they arise much nearer the branchiostegals leaving a greater distance between their extremities and the plane of the commencement of the dorsal. The ventrals arise vertically beneath the sixth ray of the dorsal, are orange in color, and margined anteriorly with white. Their outer circumference is slightly oval. The anal is not so high as the dorsal by one-quarter, while in the *siscowet* it is of equal height; terminal line obtuse and parallel with the axis of the dorsal. These fins are of an orange hue, and tipped with white or light gray. The dorsal arises in the middle of the back, is of a dark-gray color, and spotted in the form of transverse bands—terminal line obtuse. Caudal long and much furcated, much more so than with the *siscowet*; nor does age change much the acuteness of its terminal line.

The branchiostegal rays are twelve in number, and are of a pure white, except the last, which is irregularly spotted with gray. Eye large and circular, with irides of a golden yellow, and pupil angulated toward the snout, which is obtuse. The upper maxillaries are longest, and at their union show in both sexes a singular depression, into which is received the curve of the lower maxillaries.

The maxillaries, intermaxillaries, and palatines have each a row of

conical and inflected teeth. Those upon the lower maxillaries are large and strong; those of the intermaxillaries are next in size; upon maxillary and palatines next in size, and those upon the vomer smallest, numbering only three or four, and not confined to the anterior extremity, but extending a good way backward. The tongue is deeply grooved, and furnished with inflected teeth, arranged in lateral rows.

The opercular apparatus is somewhat concealed by the thick skin which envelopes it, but the outer lines of the operculum are quite distinctly marked. The operculum is quadrilateral, of greater height than breadth, well rounded in its posterior free margin, denticulated in its lower, and nearly square in its upper, the anterior angle of which is characterized by a strong and prominent process. Suboperculum is nearly one-third smaller than the operculum, is triangular in its upper portions, elliptical in its lower borders, and terminates at its articulation in the form of a fish-hook. The interoperculum has, as usual, the form of a long square, but square on the posterior side, and forming an acute angle with its lower margin, slightly rounded on the anterior side. Finally, the preoperculum is long, slender, crescentic, and almost vertical in its position; it is thick and furnished with a prominent ridge and three foramina upon its anterior surface.

This trout inhabits many of the great lakes and deep mountain-tarns of Maine and New Brunswick; but it is believed not to exist in those of Eastern New Brunswick, which singular hiatus in its distribution perhaps may be explained by the absence of deep waters in that country.[a] It haunts the deepest waters, where the cold, or the repose to which it leads, favors that development and conservation of fat which is, indeed, a characteristic, and it steals forth in quiet at the approach of twilight or at early morn to the shoals and the shores in quest of its prey, which consists for the most part of the *Lota* and *Cyprinidæ;* but its baffled voracity often contents itself with substances entirely foreign, as its stomach presents sometimes a heterogeneous mass of bones, leaves, twigs, and fragments of decayed wood.

Its habits vary in some localities. In certain lakes they are bold, and, ranging near the surface, at times may be taken by trolling, but never rising to the fly, while in other lakes they are timid, and seek the obscurest recesses; thus, for instance, their existence in the Tunk Lakes was unknown for more than half a century to the inhabitants living near their shores.

Its mysterious nature has furnished the all-observing Indian with some proper idioms, and it appears again in the vague mythology and wild legends of that almost extinct race. Its names are various among the different tribes; and if the present are not of the half-breed Canadian date, they are, perhaps, of recent origin, since the few remaining dialects have changed greatly within a century past. Considering, then, the uncertainty of its ancient name, and the diversity of its synonym, I propose my friend Toma of the Openangos.

XI.—*THE LAKE TROUTS.

By A. Leith Adams, M. A., M. B., F. R. S., F. G. S.

The non-migratory lake trouts of North America, as far as has yet been ascertained, comprehend three forms, to which the following specific names have been given: the Namaycush, or Great Trout of the Lakes: the Togue, or Gray-spotted Lake-Trout; and the Siscowet. The first was described by Pennant, at the close of the last century; the second by Dekay, in 1842; and the third by Agassiz, in 1850. According to the present state of our knowledge of their haunts, it appears that the Namaycush inhabits the great lakes extending from the Northern United States to the Arctic Sea. The Togue is said to frequent only the New England, Nova Scotian, and New Brunswick lakes, including the State of Maine, while the Siscowet is seemingly restricted to Lake Superior, where Agassiz also recognized the Namaycush. But little is known of their habits; moreover, several instances have occurred lately of one or other of these trouts turning up in lakes where their presence was unsuspected; it is, therefore, not unlikely, when their geographical distributions are better worked out, that this seeming partiality to certain waters may, after all, be more apparent than real. Further, it appears that their claims to be considered distinct species rest altogether on certain minor details of structure and coloring in each, which, however, have been further abridged by late researches. It will not, therefore, be surprising to such observers as may have enjoyed opportunities of studying them in their native haunts, should these so-called species turn out to be only varieties of seasonal or sexual conditions of one gray-spotted lake-trout, common to the boreal regions of the continent. I shall now point out the recorded differences between each, together with my own personal observations of the Togue, as met with within the boundaries of our region.

The Namaycush, Mackinaw salmon, and salmon-trout of the Canadians is known to Indians by various other names. It was first described by Sir John Richardson, who gives a lucid account of the fish.† The most noticeable differences between it and the other two are in the formation of the labials, where the crest projects beyond the limb of the bone, the latter being not quite three times the length of the in-

* From Field and Forest Rambles, with notes and observations on the Natural History of Eastern Canada, by A. Leith Adams, M. A., M. B., F. R. S., F. G. S., Staff Surgeon-Major. London, Henry S. King & Co., 1873.

† Fauna Boreali-Americana, part third, The fish, p. 179, pl. 79, 85.

termaxillary. This peculiarity (if persistent) is certainly very characteristic of the Namaycush. The ventral fin is placed farther back than in the Togue and Siscowet, and the tail is more forked. There is a double row of teeth, extending at least half an inch backward on he vomer. The teeth, gums, and roof of the mouth have a tinge of purple, hence Mitchill's name, "Amethystine Salmon."

The Siscowet is known by this native name apparently in contradistinction to the last, which is also found in Lake Superior. The former appears to be very plentiful about Isle Royal. Agassiz makes out the following distinctive characters; but as many are also common to the other two, I merely indicate the discrepancies. The lower branch of the pre-operculum is more extended than the upper. The pectoral fin is longer, and farther from the gill-opening, than in either of the other two trouts, and the dorsal is said to be larger, with a more slender and less club shaped adipose fin. The anal is as high as the dorsal, but not so long.

The Togue was supposed to be identical with the Namaycush until Dekay's description, when he named it *Salmo confinis.*

I find, however, that his so-called differences are in several instances not general; and perhaps a better acquaintance with their natural histories will further establish a closer connection between the two. For several years this fish, as met with in our waters, was supposed to be dentical with the Loch Awe trout *S. ferox*,* from which it seems to differ in many points.

I had abundant opportunities of seeing the Togue at all seasons and in various stages of its growth, so that, as far as the denizen of our forest-shaded lakes is concerned, I believe the following will be found to be an accurate description of its appearance and habits.

The external coloring varies, of course, according to the nature of the lake-bottom, and whether or not the individual may have been caught during the breeding-season. When in full vigor, in October, during the spawning-month, the males, with the exception of the unusually large individuals, will be found very much alike, and more or less of a dark greenish-gray, getting fainter toward the belly, which is dappled with dull and purer white patches. The yellowish-gray spots, some as large as buck-shot, extend over the body and tail. The latter is said *not* to be the case in the Namaycush, but, from Agassiz's drawing,† they are evidently present on the tail of the Siscowet.

There is more or less of an orange tinge on the lower fins, especially the pectorals, but the purple in the inner surface of the mouth of the Namaycush is seemingly absent in the Togue.

In full health and vigor, the Togue presents a close resemblance to the

* Mr. Perley was, I believe, the originator of this opinion, from a comparison between figures and general descriptions of the European fish.

† Lake Superior, pl. 1, fig. 3.

full-grown salmon. The head forms one-fourth of the total length from the snout to the tip of the caudal. It is rather flat above and convex in profile. The eye is midway between the tip of the snout and the nape, and about twice as near to the former as to the hinder edge of the gill-cover. The labials are fully three times as long as the intermaxillaries, thus contrasting with the Namaycush, but identical with the Siscowet. The labial crest does not extend beyond the extremity of the bone, as it does in the Namaycush. The length of the lower jaw is equal to that of the upper surface of the head. Like other lake and river salmonoids, it has a prominent knob on the extremity of the lower jaw, which in ordinary-sized males is not permanent, and only seen during the spawning-season. In old males, however, it is very conspicuous, and, as in the salmon, fits into a cavity in the upper jaw; indeed, it would appear to become developed with age, so that all very large salmonoids have it more or less throughout the year. The gill-covers are almost similar in the three, and broadly distinctive as compared with the brook-trout and the sea and salmon trouts, while the outline of the gill-cover, and the relative dimensions of the operculum, and its points of junction with the suboperculum, in all the American lake-trouts, assimilate closely to the salmon *S. salar*, while the crescentic outline of the pre-operculum is broadly distinctive, and resembles that of *S. ferox* of Europe.

In the New World lake trouts, the pre-operculum bulges to a degree, owing to the enormous development of the great masticating muscle in front. The general features of the opercular apparatus in lake-trouts, as compared with other salmonoids, are distinctive. The operculum is four-sided, well rounded, and of greater height than breadth; the suboperculum is nearly one-third smaller than the last, and is triangular in its upper half, elliptical in its lower borders, and terminates at its articulation somewhat in the form of a fish-hook. The operculum, with the exception of the Siscowet, is long, slender, crescentic, and almost vertical, with a prominent ridge, and the usual foramina upon its anterior surface.

The teeth of the Togue are strong, slightly curved, and conical; those on the outer and lower maxillaries are the largest. The vomer is armed with a few teeth in a cluster or in regular double row, as is said to be the case in the Namaycush; although in the young of the former the teeth run in a zigzag way down the bone in a single row for some distance, but in old fish there are usually seven. Two adult male Togues examined by me gave the following formula, which it may be remarked is absolutely identical with that given by Richardson as the scheme of dentition in the Namaycush, viz: intermaxillaries, 7–7; labials, 19–19; palatines, 13–13; lower jaw, 19–19; tongue, 8–8; vomer, 7–7.*

It is worthy of note that in young and adolescent individuals of the

* Fauna Boreali-Americana, part third, Fish, p. 182.

Togue, a third row of teeth is frequently observed on the center of the tongue, where sometimes one or two may be met with in the adult.

The fins vary considerably. By compounding many notes taken at different times from a large number of specimens, and striking an average, I found that the same discrepancies are applicable to the three American lake trouts.*

The adipose fin is club-shaped in the Togue and Namaycush, and, as before stated, not so long and slender as in the Siscowet. The specimen represented in page 235 † was a very fine Togue, captured during the spawning season in the Toledi Lakes, Upper Saint John. It displays the powerful proportions of the fish at this time of the year, which are very different to what obtain subsequently when fecundation has taken place. The scales of this species, and seemingly of the other two, are small and elliptical, decreasing in size from above downward. I counted in two instances 132 along the lateral line, which some authorities state takes its origin at the upper angle of the operculum; but this statement, made, I believe, originally by Dekay, is incorrect in the case of the Togue, and it would appear, also, in the other two. The line commences at the upper third of the operculum and curves slightly downward until beyond the pectoral fin, when it runs straight for the tail. The latter, although furcate in the old, is by no means so in younger individuals. There is often an abnormal thickening or enlargement of the lower caudal lobe, which I have seen in several instances, and the same has been noticed by other observers. It is met with in both sexes, but whether congenital or induced I cannot say; it may have originated from the friction in digging the sand for the deposition of the ova. I counted 130 pyloric cæca and 62 vertebræ ‡ in two females of the Togue.

The Togue abounds in the great lakes at the sources of the Saint Croix and Saint John Rivers, deriving one of its local names from the Toledi Lake, where, and in Lake Temiscouata, it is extremely plentiful. Dr. Gilpin, of Halifax, seems to have been the first to proclaim its presence in Nova Scotia. According to Dekay, it is common in the lakes of New England, where Europeans give it a variety of names; its western and northern extension, however, is imperfectly noted. I am unaware of the Namaycush and Togue having been met with in the same waters. The partiality of the latter for certain lakes, or at all events its seeming absence from others to all appearance better adapted to its habits, may be more apparent than real, seeing that, like non-

* Thus in the Namaycush, Siscowet, and Togue, the fin-rays are as follows: Gill-rays, 12–13; D, 12–14; P, 12–14; A, 11–13; V, 9–10; C, $19\frac{6}{6}$–$\frac{5}{5}$.

† "Illustration of the togue or grey-spotted trout of the lakes." Field and Forest Rambles.

‡ Holmes, in the Maine Agricultural and Scientific Report, 1862, p. 110, gives 113 cæcal appendages and 65 vertebræ, which, unless it is a mistake, shows considerable irregularity in the numerical proportions of the former.

migratory lake trouts in general, it passes much of its existence in the profoundest depths, as is shown by the frequent use of a thirty-fathom line in fishing for Togue through the ice. It repairs to shallows to feed on trouts, smelts, and the like; indeed, the last-named fish would appear to constitute its favorite winter-subsistence, inasmuch as out of several individuals dissected by me in midwinter, and from different lakes, all contained smelts. It preys extensively also on eels and cyprinids, and is in fact a tyrant with an appetite so voracious, that quantities of twigs, leaves, and fragments of wood are constantly found in its stomach. The great monster will sometimes rise to spinning tackle, but in so sluggish and undemonstrative a manner, that the troller may fancy he has caught a water-logged pine or stone. In this way I had my line checked on the Schoodic Lake, when, striking gently, I found I had missed a large Togue, whose trenchant teeth had made a series of deep furrows in the chub with which the hook was baited. It is rare for this fish to rise to spinning tackle, and the Indian who steered the canoe assured us that he had not seen the like before. No doubt the flashing of the blades attracted the monster, to find the chub on the hook. It is naturally sluggish and inert, and apparently much of a bottom-feeder. As we glided along the shore of one of the islets, composed more or less of granitic bowlders, our attention was directed by the guide to a large black object on the bottom, among a mass of stones. This he asserted was a monster Togue, which, if such was the case, must have exceeded three feet in length; moreover, he showed us two notches on the side of his canoe, representing the dimensions of an enormous individual, which an Indian had speared in the same waters during the spawning-season, the admeasurement being no less than four feet five inches.

The average weight of the Togue is seemingly about nine pounds, but this may not be altogether correct. I have seen individuals weighing fifteen pounds, and fishermen and Indians speak of having captured Togues from twenty-five pounds to thirty pounds, and even forty pounds in weight. Probably the largest seldom leave the deep bottoms of the great lakes. A noble specimen of this uncouth-looking denizen of these forest-shaded lochs is now before me. If ever bull-trout deserved the name, those prominent eyes, huge muscular jaws, broad back, deep sides, with the force of the frame centered in front, might well win that appellation for the Togue, The Indian indulges his love of the marvelous when talking of him; and although often impromptu stories are got up to amuse and impress you with the learning and knowledge of the speaker, still, even in the absence of unwritten history, one may detect figments of their wild legends and mythology strangely mingled even with the traditions of their earliest Christian instructors, of monster Togues and Sturgeons that appeared on the surface of the lakes at night, striking such terror among the tribe that they were forced to abandon their hunting-grounds; indeed, such, with the pigmy fairies,

giants, and other offspring of their ever-fruitful imaginations, rendered famous whatever localities the apparitions were said to frequent.

Raftsmen accustomed to pass along Grand Lake assured me that they had often seen a shoal of Togues depositing their spawn, and surrounded by thousands of eels, hornpouts, dace, &c., which assemble to feed on the ova; moreover, that neither the males nor the females remain beyond a few days on the ground. Sometimes the roe is deposited between stones, where the males may be observed fertilizing it. At this season the Indian plies his spear unmercifully, killing hundreds and wounding more. The flesh varies in color, from orange to cream color—according, I imagine, to the season of the year. As an article of food it is very fat, with little flavor, unless in the shape of "fish-cake well seasoned by Harvey's sauce," when the fisherman's appetite will pronounce it a delicacy, only surpassed a hundredfold by a broiled or fried brook-trout, or its congener the silvery salmon-trout.

XII.—ON THE SPECKLED TROUT OF UTAH LAKE.

Salmo Virginalis, Girard.

By Dr. H. C. YARROW, U. S. A., *surgeon and naturalist of the expedition for explorations and surveys west of the* 100*th meridian, in charge of Lieut. G. M. Wheeler, United States Engineers.*

The lake trout, or, as it is sometimes called, the brook and speckled trout, by the inhabitants of Utah, is one of the most characteristic and numerous fish of the Territory, affording a valuable, healthy, and cheap article of diet. This fish has existed for years in immense numbers, and for this reason it is rather singular that its occurrence was not noticed until the party under Lieutenant Wheeler, of the Engineers, visited Utah Lake in 1872. This fish is found in Utah and Pangwitch Lakes (the latter in Southern Utah) throughout the year, being most abundant during July and August, at which time these notes were hastily made.

In comparison with the other fishes of Utah, the lake trout is undoubtedly the most numerous and most easily captured; how long, however, this condition of affairs will last it is impossible to say, the supply having greatly diminished during the past few years, owing to reckless methods of fishing and increase in the number of fishermen; moreover a larger demand is now made for this fish, owing to increase in the number of settlers. The decrease in the yield may be roughly estimated at about one-third, but this percentage is slowly but surely increasing. The greatest size this fish attains, as far as could be learned on inquiry and from personal observation, is three feet; weight about fifteen and a half pounds. The average length, however, is about fourteen inches, and average weight one and a half pounds. The rate of growth is not known, although it is stated by the fishermen to be perhaps an inch per annum, but according to my own belief the rate is greater. The fish is supposed to attain its full size in about five years. In shape there is very little difference between the male and female; though near the breeding season the female is the larger and more brilliant in color. This increased brilliancy of color affects both sexes, but is noticeable in a more marked degree in the female. About breeding-time the eyes are brighter, scales more brilliant, and the superficial blood-vessels more fully engorged than ordinarily; the movements are more rapid, a celerity being displayed quite at variance with its usual somewhat sluggish habits. This fish winters in the deepest waters of the lakes, as most of the mountain streams to which it resorts in spring and summer are shallow and very cold. The male and female, large and small, run indiscriminately together, the presence of this fish in any

particular locality being indicated by the presence of flocks of birds hovering over the water. Except in the month of July, when unusually sluggish, the lake trout may be taken at any time with the hook and line, and, being high-spirited and particularly gamy, affords excellent sport for the angler. In summer it swims low in the water, in order, I think, to avoid the extreme heat of the sun. In winter it prefers the deepest water.

As far as could be ascertained the spawn has not been observed to run from this fish when captured, either by the line or net, for the reason, most likely, that the gravid female is seldom taken just prior to or during the time of spawning. It first enters the mouths of mountain streams and rivers to spawn about the middle of March, remaining until the middle of May, by which time the majority have fulfilled their reproductive functions. It is at such times that the fishermen, lying in wait at the mouths of the rivers, are able to capture such enormous quantities. In coming on to the breeding-grounds all sizes are found together, young and old, little and big. The favorite localities for feeding in summer are close to the mouths of rivers, the water of which from the mountains is ice-cold, from ten to twelve feet deep, and the current very swift. As already stated, the cold water is preferred in summer and warm in winter.

After spawning the trout invariably swim in schools, from one part of the lake to the other, in search of food, a solitary fish at such time being seldom seen; in traveling the trout is nearly always accompanied by its friendly companions the mullet, sucker, &c., which share with it the danger of attack by man and birds.

Notwithstanding the apparent affection existing between the different species of fish in Utah Lake, the trout does not hesitate to prey to a large extent upon the young of other kinds, suffering itself, in return, in the same way, but in a much less degree. The trout is very voracious, devouring other fish smaller than itself, particularly a species locally known as "silver-sides," of from two to six inches in length; on dissection, I have found the stomach of the trout crammed with these little fish. Grasshoppers, too, are a source of diet to the trout, with flies and other insects, while they do not disdain even snakes and frogs of tolerably large size. With regard to the methods of feeding I have not been able to perceive or otherwise learn of any peculiarities of the trout unless it be the great eagerness with which they seek their food, and the rapidity of devouring the same, especially with reference to bait on the hook. The quantity of food it consumes, judging from personal observations and accounts of experienced fishermen, must be enormous. During the spawning season no very observable changes take place in the trout except those mentioned above, and also, that the under part of the cheek of the female becomes very bright. As a rule, it may be stated that in general appearance the male is much brighter than the female at this season, and that the former is the smaller.

Before spawning the nest is made in the sand or gravel by a rotatory motion of the tail of the male. Into this cavity the eggs are exuded by the female, which is sedulously guarded by the male until the process is completed, when the latter deposits the milt which is to impregnate the eggs. No further care is taken by either after the deposition of the impregnating substance. Most of the spawning is done in the rivers, but the process takes place in the lakes also to some extent. Spawning is greatly interfered with by the nets used by the fishermen; knowing the time when the fish begin to run up the rivers, the nets are drawn near the mouths of the waters, and large numbers of fish taken. It is not known at what age this fish begins to breed, nor what period of time the process continues, although both these points might be definitely ascertained by careful observation of captives under favorable circumstances. The act of spawning exerts an injurious effect on the flesh of the fish, rendering it poor and insipid. In addition, many of the fish seeking the upper parts of the rivers, to fulfill their reproductive duties, do not survive the severe bruises and other injuries they meet with in the journey past the rocks and through the rapid currents of the mountain streams.

The water in the locality in which the trout spawns has never been noticed to be whitened by the milt, but it does present a translucent pinkish appearance after the event.

The temperature of water most favorable for hatching appears to be the coldest obtainable, the eggs, in many cases, being laid directly on the bottom of ice-cold mountain springs. The color of the spawn is whitish pink, each egg, just previous to spawning, being of the size of No. 4 shot. In July the eggs are not larger than No. 12, or dust-shot. The eggs, when spawned, always sink to the bottom, where they remain unless eaten or carried away by the swift current. As already stated, the nest is made from gravel and stones entirely, no other materials being used as far as has been observed. The eggs are hatched in March, April, and May, but the number of days required by the process is not known. The spawn and young fish suffer greatly from the attacks of other fish, aquatic reptiles, and even from the large fish of their own species, these seeming to have no affection for their young. It is rather a singular fact that the very young trout is seldom seen or taken either by the hook or net, and I am unable to account for the same unless it is that it resorts to unknown localities until a larger growth is obtained. Its food, so far as known, consists principally of small insects.

No steps have as yet been taken to increase the supply of this valuable fish by artificial means, the yield still being large enough to meet the wants of the settlers and miners; but in the course of a few years artificial propagation must be resorted to, for although certain laws have been passed regulating the size of the meshes of nets, no attention is paid to them by some greedy individuals, who think only of filling their own pockets at the expense of future generations.

It may be mentioned in this connection that a letter, prepared at the request of the Hon. G. Q. Cannon, and bearing on this subject, has been presented to the legislature of Utah. It suggests the enacting of certain laws with reference to the preservation of fish, &c., and that the same be rigidly enforced when passed.

No epidemic causing sickness or destruction of life among the trout of Utah and Pangwitch Lakes has ever keen known, nor is this fish ever affected with parasites, as are many of the marine species. I must state, however, that I have been informed by a trustworthy friend that the same fish of the lakes in the Yellowstone region is uneatable in the summer, its flesh being riddled and filled with parasitic tape-worms of considerable size, many, according to Dr. Leidy, being *five inches* in length. Mr. Carrington, whose notes accompanied the specimens examined by Dr. Leidy, states that the smaller worms were contained in cysts adherent to the exterior of the intestines, while the larger ones up to six inches in length were found imbedded in the flesh. From five to fifty of the parasites were found in a single fish. When numerous they appeared to affect the health of their host, and the fishes most infested could generally be told by their duller color, meagreness and less activity. Dr. Leidy states that this worm belongs to the genus *Bothriocephalus*, or rather to that section of it now named *Dibothrium*. Two species have long been known as parasites of the salmon and other members of the same genus of fishes in Europe; but the tape-worm of the Yellowstone trout appears to be a different one, and may, from the shape of its head, be named with propriety *Dibothrium cordiceps*.

The trout of Utah Lake may be taken at nearly all seasons by both hook and net at all times, but in Pangwitch Lake by hook only, since fishing in any other way is prohibited by common consent. This, however, is no hardship, since large captures are easily made with the hook, I myself having taken from thirty to forty pounds weight in a single hour's fishing. The hooks used are simply large steel ones, with a snood, or snell, of piano-wire, which is strong and flexible. The best bait is minnow and grasshopper, although this trout will bite at almost anything. In Pangwitch Lake a fish's eye is considered a very tempting bait. The nets used in Utah Lake are made of Nos. 9, 12, and 18 cotton twine, are generally four hundred yards long, eight to ten feet deep, and are furnished with brails at either end; when employed they are reeled into the boats by means of a wooden windlass in the stern. The average daily catch of one person with hook and line would perhaps be twenty pounds, or about thirty-six hundred pounds the entire season; for a net of the dimensions above specified, one hundred and fifty pounds daily in summer and thirty or forty in winter.

This trout is highly prized by the settlers and miners of Utah, and quite a large proportion of those taken are consumed in the immediate neighborhood; the remainder is sent to the different mining camps, settlements, and the Salt Lake City market. As an article of food its

excellence is not surpassed by any fish, either fresh or salted. The delicacy and firmness of its flesh commend it to all who have a preference for fish-diet. Furthermore, it retains for a longer period than most fish its unequaled and unique flavor. All that are captured are readily disposed of, mostly in a fresh state, though a few are salted and smoked. In no case is it used for manure, nor is it ever exported. The retail price of the fish in its fresh state varies from twenty to thirty cents per pound; wholesale, from ten to fifteen cents; salted ones bring from ten to fifteen cents. These prices are about those formerly obtained, and are now current in the Salt Lake market.

The foregoing observations, as already stated, are the result of notes taken in Utah in July, 1872, by my assistant, Mr. Henshaw, and myself, though in some instances valuable aid and information were obtained from Mr. Peter Madsen, an intelligent Danish fisherman of Utah Lake, who kindly placed at our disposal data obtained during many years' experience acquired in this locality.

In conclusion, it may be stated that the Utah Lake trout is of vast economic importance to the settlers of the Great Salt Lake Valley, supplying as it does a comparatively cheap and most excellent article of sustenance, and one to the preservation of which special attention should be speedily given, since, if means are not shortly taken to prevent the destructive methods of fishing now employed, the species must become extinct after a few years. A number of fishermen, having no fear of the law, which is virtually a dead letter, are in the habit of visiting Utah Lake from Salt Lake City and other localities, and make use of nets of very small mesh for the express purpose of taking in the small fish, which readily sell for ten cents per pound in the Salt Lake market. As already mentioned, this reckless and destructive mode of fishing is in no wise tolerated by the people of Pangwitch, nor should it be by the residents of Provo City, near Utah Lake. Mr. Madsen, who lives on the lake, and who has been engaged in fishing for the past eighteen years, complains bitterly of these interlopers and law-breakers, as he finds his profits are gradually decreasing with the number of fish from year to year. He mentions that, in 1864, such was the abundance of this fish, that in one haul of the seine, discarding all other kinds, he secured between thirty-five and thirty-seven hundred-weight of trout, while at the present time five hundred pounds is considered an enormous haul.

In September and October the trout are somewhat scattering and do not approach the shore; consequently large hauls are seldom made at this period. Mr. Madsen states it as his opinion that the female in spawning ejects only a portion of her eggs, as he has found on dissecting the trout after the spawning season eggs of various sizes, some very small and others full grown. The manner of seine-fishing in the locality mentioned is quite similar to that pursued in the East, excepting that two boats are used instead of one, the seine being paid out from one of the boats, which generally takes position to the southward

of Provo River, while the other, with a line attached, makes a semicircle. As there is a perceptible current setting from the southern arm of the lake, increased by the southwest wind, the net is gradually drifted to near the mouth of the river; the boats then approach each other, the brails are seized, and the lead-line is held down by the feet of the fishermen, who jump into the shallow water into which the net is drawn, the fish being secured as the net is gradually hauled in. In winter fishing is carried on under the ice, holes being cut at certain distances and the net introduced by means of spars; it is then dragged to a favorable open space, and the fish collected. The hauls in winter, however, scarcely repay the labor bestowed; the net is sometimes seriously damaged, and the trout are shy and run into deep water; but the so-called suckers are very numerous, and meet with a ready sale.

The accompanying maps will afford a better idea of the lakes in question and their tributaries than any description I could possibly give. They are copied from the maps of Lieutenant Wheeler's report of the Territory, and are reliable. To this gentleman I am indebted for permission to publish these observations, which form part of his Report on the Ichthyology of the West.

XIII.—MISCELLANEOUS NOTES AND CORRESPONDENCE RELATIVE TO SALMON AND TROUT.

A—ON THE SALMON IN MAINE.

DENNYSVILLE, ME., *August* 3, 1872.

DEAR SIR: When you were here, I did not have time to give any intelligent information concerning the salmon, its habits, &c. I am sorry I do not have the positive knowledge which would be of most service to you, but, in place of that, will give you some indirect, some *circumstantial* evidence which may serve some purpose.

I have been surprised at seeing how late the deposition of the spawn is now considered to take place, and I am not ready to believe that under normal conditions, at least on this river, it is anywhere near so late. I myself have never seen their operations.

My notion has been that the large early salmon deposited their spawn as soon as they reached the proper places. Certainly, many of them seem to be as forward as the alewives, who hardly get above the dam before commencing, the most forward of them, to leave their eggs; for small alewives are ready to return at so early a period that they must have begun growing in May. These get to be about as long as one's finger when they come down the river, and schools of them, probably from later and later deposits, keep coming down till after the river freezes, and two years ago masses of them got entrapped in the "anchor-ice" in Meddybemps Lake, and were then washed ashore and perished in windrows on the beach.

Now, some few things as to the salmon. Years ago they could be caught by the boat-load. They were too numerous to escape the same observation which the alewives attracted. I never heard of anybody who knew, or supposed, or suspected anything to the contrary of their coming down the river and going right off to sea as quick as they became large enough to swarm, there to remain and get their living, where alone a living was to be had, till they became large enough to return (some two or three years) and leave their own fry, which would correspond, perhaps, to the later alewife-fry. If young salmon (other than the little fry hurrying off to sea) were caught, or were in the river—that is, if they hung around and went up stream the next season, and the next, I cannot but think we should have found it out, some of us. My eyes were certainly sharp enough to know a trout when I saw it—and I caught any amount of them—and to be safe from confounding it with a young salmon; and if blind, I should have found out the difference by the taste.

As I think I told you, from earliest spring till late in the summer, there were always (more formerly than now) weirs up and down the river from just below my house to the falls, in which salmon, alewives, herring, frostfish, smelts, sturgeons, &c., were caught, as well as a few nice but unmistakable trout; but in all this period I never knew of but two young salmon, children, to be caught. These were caught in one tide in one weir down the bay, some fifteen or twenty years ago, and we had them cooked, and ate them.

Of course, if two have been caught, others may, and probably have been; but in that time hundreds of shad, and bass, and mackerel have strayed away from their fellows, and been caught also; so that it is hard to regard the coming of these young salmon as otherwise than exceptional in this little river. In large rivers, where there is more to eat, it may be different.

In late years, now that there are legions of little boys fishing in the fall of the year in the pond at the mills, it is reported that they have occasionally drawn out, with the chubs and trout, a very small specimen of a salmon, about as long as a smelt or a very small trout; and I presume that always, when the gates of the water-wheels were shut down, and little alewives were stranded in the puddles underneath, that salmon-fry were with them. The men sawing would have expected nothing less; and it would probably have been only the uniform absence of salmon-fry that would have excited any attention or remark. This is the way it seems to me. Of late years, the number of fish has been too small to give much of a chance of stranding a little one, even if the old rocky puddles had been left in condition.

More than this, it does not seem probable that a year-old fish would ever trust himself up the river, unless he were a candidate for starvation. There are flies enough to support a few chubs and trout, and that seems to be all. The salmon and alewives seem to deteriorate rapidly in condition with every step they take from the sea to the highest point they reach. Those taken much above the mills we think of little account. Coming in from the sea, at the mouths of the bays, salmon are occasionally caught with a codfish-hook and a piece of pork, perhaps, and when they are leaving the river, black, and eel-shaped, and ravenous, they have been caught in that way also; but between these two periods, they seem to subsist upon and consume their own substance laid up at sea, together with what few insects they pick up. The young of the alewives are grown in the large shoal lakes, where there seems to be some little chance of subsistence for a small fish, while the salmon is confined to the little stream itself, with its scanty supply of food.

I hope I have not tired you with these details, which possibly you understand very much better than I.

Yours, truly,

THOMAS LINCOLN.

Professor S. F. BAIRD.

B—ON STOMACHS OF SALMON AND THEIR CONTENTS.

1.—ON THE CÆCAL APPENDAGES OF THE STOMACH.

NEW HAVEN, *February* 22, 1873.

DEAR SIR: I looked over some salmon-stomachs last November. I told Mr. Smith the result, and supposed that he put this item in with his report to you. I learned the other day from him that this was not the case.

The fact was, that there was no regularity in the number or arrangement of the cæcal appendages. They ran all the way from 44 to 70, gradually, continuously, and without grouping.

Very respectfully,

JAMES K. THACHER.

Professor S. F. BAIRD.

2.—ON THE CONTENTS OF THE STOMACH.

NEW HAVEN, *November* 11, 1872.

DEAR SIR: I have carefully examined the salmon-stomachs, sent on a few days ago, but find nothing in them which could have served as food. The stomachs themselves were entirely empty, except one, which contained a single specimen of the external, Caligus-like, parasite, sent by Mr. Atkins as from the salmon. This may have been accidental. The intestines usually contained, especially in the pyloric region, considerable mucus, which revealed nothing under the microscope. In several specimens, the intestines contained a few fish-scales, which, I presume, are those of the salmon, as they were also frequently found upon the outside of intestines, and loose in the packages.

In one specimen, there were two small bits of wood in the intestine These specimens, with a few intestinal worms, which were found, I have preserved to return with the stomachs as soon as you wish.

Very truly, yours,

SIDNEY I. SMITH.

Professor S. F. BAIRD,
Washington. D. C.

[According to Dr. A. C. Hamlin, the examination of many hundred salmon in the Bangor market revealed no kind of food, excepting in a single instance, where two small fishes were discovered.—S. F. B.]

C—ON THE SILVER-TROUT OF MONADNOCK LAKE, NEW HAMPSHIRE.

KEENE, N. H., *October* 30, 1872.

DEAR SIR: I send you by express to-day a few specimens of the "silver-trout," or "Dublin trout," as they are called here. They were caught in Center Pond, in Dublin, yesterday, and are fair specimens of the variety found there.

The pond lies at the foot of Monadnock Mountain, and is sometimes called Monadnock Lake. The shores and bottom are covered with a fine white sand. The water is always much colder than that in the neighboring ponds, as it is fed only by deep springs, there being no stream running into the pond. The water is also very clear. In the pond are a few dace, perch, and eels, which are not in any way peculiar. I believe the flesh of these trout is a fine salmon-color, and they have a great local reputation for the angler and for the table since the settlement of the country. They are caught only in May or June and in October, when they seek their spawning-beds in the shallows of the pond. Great numbers were formerly taken from the spawning-beds, but they are now protected by law at that season. They are thought by our anglers to be a different species from the brook-trout of our New Hampshire streams, and by some are claimed to be "land-locked salmon." I hope these specimens may enable you to decide these questions. As the colors will be damaged by the alcohol in which I send them, I give you the notes of the coloring of a female, measuring nine inches in length and weighing four ounces: iris, dark-brown; upper part of head, black; gill-covers, silvery white, with prismatic reflections; lower jaw, white, with a dark line near the mouth; back, light olive-green; sides, light-green to lateral line, and then much lighter, shading rapidly to white of belly, the whole gleaming like silver in the sun-light, even under water; belly, white, tinged with bright vermilion. Sides covered with golden spots, rather faint in color, from one-eighth to three-sixteenths of an inch in diameter; lateral line very distinct; the pectoral, ventral, anal, and caudal fins bright vermilion, with the larger rays in each white; the dorsal and adipose fins olive-green, mottled with brown; the scales are small, but very distinct. The male is darker colored, with much more red upon the belly, and has small red spots in many of the yellow spots, resembling much more some of our brook-trout. I may add that no other pond, as far as I have learned, has trout marked like these.

Hoping these specimens may arrive safely and in a satisfactory condition, I remain, yours, truly,

THOS. E. HATCH,
Com. on Fisheries for New Hampshire.

Professor S. F. BAIRD.

[These fish proved to belong to the group of lake-trout, probably closely related to what Dr. Prescott called *Salmo symmetrica*.—S. F. B.]

D—ON THE EDIBLE QUALITIES OF THE SACRAMENTO SALMON.

SAN FRANCISCO, *August* 1, 1872.

DEAR SIR: Your esteemed and very interesting favor of the 12th ultimo reached me not until yesterday, owing probably to some irregularity of the mail. It is quite encouraging to us out here to learn that the commissioners of the Eastern States are taking an interest in the fishes of this coast. Born and raised on the Atlantic seaboard and accustomed from my boyhood to fishing in its waters, I have found much to interest one in the marked difference of the fishes of the Pacific coast from those of the Atlantic.

As a rule (with the exception of the salmon) the fish of this coast are not so good in quality not so reliable in quantity, neither are there large runs of migratory fish, as is the case on your coast. The herring comes into the harbors in schools, but not in quantities. The mackerel is rarely seen, and the few that frequent our bays are small, and, as a general rule, applying to all our fish, saving the salmon, there is a want of both fatness and flavor. The halibut we also have somewhat plentiful on the northern coast, and sometimes in small numbers as low down as the harbor of San Francisco.

Our great and reliable fish is the salmon, visiting our coast, in swarms annually, from the Bay of Monterey to the extent of the Territory of Alaska. The salmon of the harbor of San Francisco are a large, fine, fat fish, and are a valuable article of food, and are sold in the season as low as five cents per pound. They are equally plenty in all the bays and inlets north of this, improving in flavor as you go farther north, until, in the bays and rivers of Alaska, they exhibit a flavor and richness utterly unknown to the epicure of the world at large. The desire of the people of California to have introduced in these waters the shad stimulated the commission to attempt the bringing across the continent the young fish from the Hudson River, and we are indebted to Mr. Seth Green for successfully placing in the Sacramento River some fifteen thousand, alive, in good health and condition, and we await with faith and patience their return from the ocean. In the mean time, I, this year provided transportation for and desired Mr. Green to send us fifty thousand more; for the purpose of pursuing the experiment yearly, until the first return might assure us of success; but the engagements of Mr. Green are such as to prevent his coming with them himself, and the difficulties of transporting them he deemed too great for him to intrust the care of them to any one else. Mr. Green has written me upon the subject of obtaining salmon-ova on this coast, and I have answered him that they can be obtained here in the vicinity of San Francisco in unlimited quantity.

Referring to the mission of Mr. Livingstone Stone, I would add that here he can have every facility for obtaining salmon-ova, and the impregnation of them. The fisheries which supply this city with salmon

are but a few miles distant, and are landed twice a day daily by steamers. The fish in full spawning condition can be obtained directly from the nets, and the transportation of impregnated spawn is available daily by express. It will give us great pleasure to meet your friend, Mr. Stone, and you will do me a favor by advising me of the time of probable arrival here, that I may be on the lookout for him. I know that he can teach us many things upon this, to me, very interesting subject, and it will give us great pleasure, not only to meet, but to be as useful to him as we can be.

With much respect, I remain, very truly, yours,

S. R. THROCKMORTON,

Chairman California Commission of Fish and Fisheries.

Hon. SPENCER F. BAIRD,

United States Commissioner of Fish and Fisheries.

E—ON THE SALMON-FISHERIES OF THE SACRAMENTO RIVER.

BY LIVINGSTON STONE.

CHARLESTOWN, N. H., *November*, 1873.

DEAR SIR: In reply to your inquiries as to the extent and nature of the salmon-fisheries in the Sacramento River, I have to say that in February, 1873, I went to the Sacramento River and at Rio Vista and other points gathered the following rather fragmentary notes, which I present here as supplementary to my report on the Sacramento River for 1872.

The fishing on the Sacramento is done in three ways: 1st, by drift-nets; 2d, by fyke-nets; 3d, by sweep-seines.

1.—DRIFT-NET FISHING.

The drift-nets are used exclusively for catching salmon. They have an $8\frac{1}{4}$-inch mesh, are usually 40 meshes deep, and from 150 to 200 fathoms long. As nearly as I could learn, there were not far from a hundred salmon-nets in operation on the Sacramento River in 1872. At the meeting of the salmon fishermen of the Sacramento that year, there were 95 boats represented.

These nets are worked by simply drifting them with the tide. The salmon, which of course are heading against the tide, are gilled in the meshes. The turn of the tide is the most favorable time for this sort of fishing.

The nets are frequently drifted a mile before being hauled in. The salmon-fishing is conducted entirely by white men, no Chinamen being allowed to participate in it. There is no law regulating the matter, but public opinion is so strong in relation to it, and there is such a prejudice against the Chinamen, that any attempt on their part to engage in salmon-fishing would meet with a summary and probably fatal retaliation.

The number of fresh salmon shipped from Rio Vista to San Francisco in the year 1872 is as follows:

January	792
February	1,581
March	1,945
April	3,354
May	4,408
June	1,201
July	1,145
August	1,496
September	2,335
October	583
November	441
December	390
Total	19,671

On one day in February, when I came down the river, there were put on board the steamer, at Courtland, 7 fresh salmon; at Rio Vista, 32 fresh salmon; at Sherman Island, 32 fresh salmon; at Collinsville, 123 fresh salmon.

The daily number of fresh fish (salmon and sturgeon) brought down the Sacramento River to San Francisco in 1872 by the steamers of the Central Pacific Railroad Company, is as follows:

JANUARY.		FEBRUARY.		MARCH.	
Date.	Fish.	Date.	Fish.	Date.	Fish.
January 1	87	February 1	326	March 1	247
2	97	2	174	2	199
3	105	3	287	3	402
4	182	4	157	4	402
5	111	5	324	5	404
6	115	6	250	6	401
7	133	7	337	7	1,030
8	125	8	393	8	344
9	113	9	334	9	139
10	199	10	282	10	334
11	211	11	415	11	272
12	224	12	296	12	356
13	243	13	280	13	316
14	112	14	228	14	135
15	166	15	253	15	447
16	234	16	432	16	283
17	308	17	247	17	419
18	214	18	259	18	255
19	172	19	348	19	501
20	302	20	408	20	425
21	73	21	285	21	452
22	294	22	389	22	106
23	210	23	249	23	516
24	221	24	223	24	396
25	210	25	334	25	192
26	267	26	276	26	253
27	112	27	292	27	241
28	46	28	395	28	242
29	76	29	272	29	384
30	301			30	344
31	141	Total	5,779	31	378
Total	5,514			Total	11,394

APRIL.		MAY.		JUNE.	
Date.	Fish.	Date.	Fish.	Date.	Fish.
April 1	243	May 1	1,485	June 1	536
2	57	2	1,758	2	....
3	198	3	1,342	3	403
4	439	4	560	4	207
5	4,711	5	....	5	229
6	114	6	998	6	174
7	....	7	1,487	7	157
8	428	8	1,298	8	75
9	372	9	1,361	9	....
10	418	10	1,046	10	175
11	599	11	482	11	220
12	578	12	....	12	300
13	310	13	431	13	357
14	....	14	578	14	348
15	589	15	689	15	210
16	960	16	1,216	16	....
17	863	17	1,668	17	564
18	879	18	712	18	307
19	643	19	....	19	306
20	581	20	694	20	158
21	....	21	929	21	41
22	693	22	899	22	38
23	905	23	859	23	....
24	827	24	950	24	89
25	1,123	25	637	25	157
26	835	26	....	26	139
27	435	27	980	27	162
28	....	28	1,193	28	100
29	1,014	29	1,297	29	109
30	990	30	1,242	Total	5,561
Total	15,613	31	603		
		Total	27,395		

JULY.		AUGUST.		SEPTEMBER.	
Date.	Fish.	Date.	Fish.	Date.	Fish.
July 1	266	August 1	454	September 1	....
2	43	2	177	2	836
3	134	3	72	3	831
4	81	4	....	4	1,269
5	73	5	560	5	1,170
6	38	6	747	6	512
7	....	7	632	7	215
8	249	8	558	8	....
9	202	9	573	9	703
10	214	10	159	10	636
11	266	11	....	11	412
12	177	12	105	12	512
13	75	13	661	13	331
14	....	14	297	14	258
15	103	15	1,014	15	....
16	140	16	798	16	890
17	281	17	186	17	786
18	276	18	....	18	1,112
19	181	19	1,041	19	1,042
20	175	20	1,205	20	461
21	....	21	1,567	21	261
22	363	22	1,499	22	....
23	330	23	1,061	23	567
24	337	24	165	24	563
25	323	25	....	25	385
26	353	26	427	26	303
27	270	27	243	27	225
28	....	28	341	28	154
29	520	29	591	29	....
30	228	30	304	30	263
31	345	31	240	Total	14,706
Total	5,043	Total	15,677		

OCTOBER.		NOVEMBER.		DECEMBER.	
Date.	Fish.	Date.	Fish.	Date.	Fish.
October 1	189	November 1	40	December 1	....
2	251	2	33	2	136
3	462	3	....	3	66
4	136	4	82	4	246
5	67	5	69	5	213
6	....	6	111	6	128
7	143	7	122	7	113
8	160	8	167	8	....
9	148	9	43	9	234
10	218	10	....	10	248
11	85	11	91	11	234
12	74	12	67	12	283
13	....	13	123	13	123
14	95	14	147	14	151
15	81	15	81	15	....
16	112	16	98	16	116
17	118	17	....	17	164
18	22	18	87	18	226
19	70	19	112	19	204
20	....	20	167	20	74
21	75	21	157	21	64
22	87	22	70	22	....
23	122	23	50	23	88
24	114	24	....	24	62
25	52	25	53	25	93
26	50	26	58	26	127
27	....	27	118	27	100
28	62	28	78	28	75
29	18	29	51	29	....
30	2	30	92	30	100
31	69			32	70
Total	3,082	Total	2,367	Total	3,716

The proportion of sturgeon and salmon in the shipments of the various months is estimated by the San Francisco market-men as follows:

January, 10 per cent. salmon, 90 per cent. sturgeon.
February, 10 per cent. salmon, 90 per cent. sturgeon.
March, 50 per cent. salmon, 50 per cent. sturgeon.
April, mostly salmon.
May, all salmon.
June, all salmon.
July, all salmon.
August, all salmon.
September, all salmon.
October, 50 per cent. salmon, 50 per cent. sturgeon.
November, 50 per cent. salmon, 50 per cent. sturgeon.
December, 10 per cent. salmon, 90 per cent. sturgeon.

Besides the salmon above mentioned, a large number are taken by sailing-vessels, and by the opposition line of steamers and other conveyances, to San Francisco and the larger towns.

The points from which salmon are shipped on the river-steamers are, Sacramento City, Courtland, Emmatown, Rio Vista, Collinsville, Antioch, Benicia, Martinez.

In the spring of 1872 about 25,000 salted salmon came from the Sacramento River to San Francisco, and in the fall of the same year about 9,000. The Rio Vista salmon fishermen recommend the prohibition of fishing from June 1 to October 1, or from June 15 to October 15.

2.—FYKE-NET FISHING.

The fyke-nets have a mesh of 2½ inches. There were in the winter of 1872–'73 eighty-five fyke-nets on the Sacramento at Rio Vista. They are stationary, of course, and are examined every twenty-four hours. All the kinds of fish that are found in the river are caught in these nets Mr. John D. Ingersoll, a prominent fyke fisherman of Rio Vista, informed me that the daily catch for twenty nets is now about seventy-five pounds of fish.

They include chubs, herring, perch, riparous, sturgeons, hardheads, splittails, Sacramento pike, suckers, crabs. Of these the perch, pike, and sturgeon are the best food-fishes, though all of the species named are sold in the market.

There has been a vast decrease in the returns of the fyke-nets during the last twenty years. In 1852 and 1853, they used to catch 700 or 800 pounds a day in one fyke-net. An average of 250 pounds a day for one net at Sacramento City was usually expected in those times. The present catch of 75 pounds a day in twenty nets, certainly presents an alarming contrast. The fyke-net fishing is conducted wholly by white men, I believe, the Chinese fishermen being ruled out by force of public sentiment. The fyke-nets are usually visited early in the morning of each day, and the catch is sent down to San Francisco by the noon boat. The fyke-net fishing begins in November and is continued till May. The best fishing is when a rise in the water drives the fish in shore where the fyke-nets are placed. During the summer months the water is warmer, the fish are poor, and the fishing is discontinued.

On the 27th of February, 1873, I went the rounds of Mr. Ingersoll's set of fyke-nets with him. We visited twenty nets, but as some of them had not been examined for over twenty-four hours, the yield was supposed to be equivalent to one day's fishing for thirty nets. The nets had four hoops each and 14-feet wings. We took out about 120 pounds of fish in all. Hardheads were the most numerous, and the Sacramento pike next. Mr. Ingersoll said that perch used to rank second in abundance in fyke-net fishing, the average for thirty nets being 200 or 300 pounds a day, but the perch were quite insignificant in numbers on this day. We found in the nets seven small viviparous perch and two small sturgeon. I learned also that mink, beaver, and otters are sometimes caught in the nets. In 1872 Mr. Ingersoll caught 8 minks, 2 beavers, and one otter in his fyke-nets.

3.—SWEEP-SEINE FISHING.

The sweep-seine fishing is given over to the Chinese, who are not allowed by public sentiment to engage in either of the other two kinds of fishing just described, but what they are not permitted to do by the prohibited methods, they make ample amends for by their own methods. They are, I should say, the most industrious and persistent fishermen on the river. They fish all the year round. They use fine mesh-nets,

with which they sweep every part of the river, especially the partially-stagnant fresh-water lagoons, or sloughs, as they are called in California, where the fish collect in myriads to spawn. With these nets they catch vast quantities of fish of all sizes, and so destructive has their fishing been on the Sacramento, that all the fish of that river except salmon are disappearing with unexampled rapidity.

It is owing to this kind of fishing that the returns of the fyke-nets have diminished so alarmingly the last few years. The Chinese have been at it for seven or eight years, and if they keep on three or four years more at this rate, the small fish of the Sacramento will be practically exterminated. I had no means of ascertaining with any exactness how many Chinese fisherman there were on the river, but there are a large number, and Mr. Ingersoll said that they were increasing every year. The most of their fresh fish they send to the San Francisco Chinese markets as soon as caught, but they also dry a great quantity of them on bars and floors prepared for the purpose. These are both eaten by themselves and sent packed in barrels to the Chinese quarter in San Francisco. While at Rio Nita in February, 1873, I visited a Chinese fishing-station on the Sacramento River. It was located about 80 rods above the Rio Nita steamboat-landing, and consisted of a nest of Chinese fishing-boats numbering seven small boats and three large ones. There was also on the shore, just across the road, two old tumble-down buildings with drying-bars and floors near by in the open air, where some of the fishermen lived and attended to the drying of the fish. The small boats were small, flat-bottomed dories, square at the stern, sharp at the bow, about 15 feet long, and strongly built.

The large boats were also strongly built, but narrow and pointed at both ends, and constructed in the Chinese fashion. Two of the three large boats had one mast, and the other one had two masts, considerably raking, with Chinese sails, which were not like anything used in this country for sails. Nearly amidships, but a little nearer one end than the other, was a tent in which the Chinamen lived. There was also considerable space in the hold of this really Chinese junk, which added a good deal to their house-room.

The whole air and look of these crafts was decidedly foreign, and I might say oriental.

If I understand their method rightly, the small boats are to visit the sloughs and various fishing points when they go out to draw the seine, and the larger boats are really only movable dwellings and store-houses, where they live and receive the fish that are brought in by the small boats, and which, of course, they move from place to place on the river as the exigencies of the changing fishing seasons may require.

Yours, respectfully,

LIVINGSTON STONE.

Prof. S. F. BAIRD.

XIV.—ADDITIONAL REPORTS RELATIVE TO THE HATCHING AND PLANTING OF THE PENOBSCOT SALMON.

A—NEW HAMPSHIRE.

CONCORD, N. H., *June* 14, 1873.

DEAR SIR: The salmon-eggs received from Mr. Atkins were hatched at Meredith with a loss of about 30 per cent., and have been turned out in the head-waters of the Merrimack, at Woodstock, Thornton, West Campton, Campton, and Plymouth, together with most of those hatched by the Massachusetts commission, which I have just turned out for them—about 160,000 in all. I placed them in the main stream at those points, believing that there are less enemies in the main stream, in proportion to the territory, and better hiding-places on the cobble bottom, than in the small streams, to say nothing of the nearer approach to their natural condition in the ordinary natural way of breeding in our streams.

I think I wrote you in relation to the hatching and turning into Winnipiseogee and Sunapee Lakes 150,000 whitefish, hatched from eggs procured at Missisquoi Bay last fall. This is the fourth year we have hatched more or less of this species of fish, all of which have been put into the same waters, with the view of showing some results as soon as possible.

Last winter or early spring, I procured some of the whitefish from Winnipiseogee for you, but they were not in good condition; and thinking I could get some better specimens, I did not send them, and I have not been able to get any of them since. I will endeavor to give you both varieties next fall, when they can be caught freely.

I have been very busy, and have had no time to prepare a paper for you on the subject of whitefish-hatching, &c., but may be able to do so at some future time.

I expect soon to carry some eggs or young fry of the shad from North Andover, below the Lawrence dam, to Winnipiseogee Lake, where thousands have been deposited within the past five or six years.

I shall soon commence operations with the black bass, and hope to be able to stock several waters with them this season.

I have the honor to be, respectfully, yours,

WM. W. FLETCHER,
Commissioner.

Prof. S. F. BAIRD,
United States Commissioner of Fish and Fisheries.

B—NEW JERSEY.

SIR: I have the honor to report that the share of the spawn of the Maine salmon awarded to the State of New Jersey, amounting to forty thousand, were shipped by Mr. Atkins per express February 25, of the present year, and arrived at Troutdale March 1.

On being unpacked, they were found to be in excellent condition, the entire loss being not over one per cent., by far the least percentage of loss of any lot of spawn ever received at Troutdale. This I attribute to the method of packing adopted by Mr. Atkins, which consists in placing fine gauze above and below each layer of eggs, the netting being attached to a wire ring. The weight of the superincumbent mass is thus evenly distributed over the spawn, and they can also be unpacked, cleaned, and placed in the hatching-troughs with much greater facility. There is but little doubt but that many eggs are destroyed by the rough handling rendered necessary in unpacking and cleaning them when packed in the ordinary manner.

The entire forty thousand were unpacked and placed upon the grilles of my hatching-troughs in less than an hour.

Few spawn died after unpacking, though some were lost by the premature bursting of the shell of the egg, an accident of common occurrence, but of which I have not as yet been able to ascertain the cause.

The trays were examined twice daily, and the young removed to the nursery-trough, on the bottom of which fine gravel, throughly boiled to free it from any dirt, had been placed. The *alevin* stage was short, the sac having disappeared by April 20. The young were then fed upon beef's-heart freed from all fibrous particles, reduced to a fine pulp in a chopping-machine run by water-power, sifted through a fine screen of wire gauze, and fed them drop by drop through a bulb-syringe. The tedium of this process may be imagined when I state that nearly three hours were occupied in feeding the lot. This is the most critical period in the existence of the young fish, and the greatest care and patience are required.

On the adjournment of the legislature of the State of New Jersey, without making any appropriation for the use of the commissioners of fisheries, I at once wrote you in regard to the final distribution of these fishes. Acting under your advice, they were placed in streams as follows: May 1, 18,000 were placed in a pond containing no other fishes, and communicating by a small rivulet with the Musconetcong Creek, a tributary of the Delaware; May 2, 15,000 were placed in Salmon Run, at the head-waters of the Raritan River; May 14, about 2,500 were placed in two streams upon the southern coast of Long Island.

Hoping that the above will meet with your approbation, I am, sir, respectfully, yours,

J. H. SLACK, M. D.

Prof. S. F. BAIRD,
United States Commissioner of Fish and Fisheries.

C—PENNSYLVANIA.

SALMON-HATCHING ON THE DELAWARE.

On March 22, 1873, by previous arrangement I received from Charles G. Atkins, Bucksport, Me., 40,000 salmon-eggs, forwarded by order of Spencer F. Baird, the United States commissioner of fisheries, to be hatched for the Delaware. I had already in position two wooden troughs, each 15 feet long and 2 feet wide in the clear, the bottoms covered to the depth of an inch with fine gravel, at Heitzman Spring, two miles above Easton, on the New Jersey side. This is a copious spring, flowing from limestone strata, a volume of about 600 gallons per minute, and the brooks, with rapids and pools, discharging, after a course of 150 yards, into the Delaware. The eggs were received with but slight loss (only 305) in transportation. The sudden transition, however, from water nearly as low as the freezing-point to spring-water at 51°, forced the hatching to such extent that there was great mortality in the embryos, many perishing with their heads and shoulders protruding from the eggs. A careful record kept by the person who had charge of the troughs shows a loss of 14,978 eggs and *alevin* from the time they were received until the last of them were discharged from the troughs—a period of about six weeks. The fry were allowed gradually to escape into the brook, as their yolk-sacs were absorbed, and at which time they commenced feeding. There are numerous large limestone-springs flowing into the Delaware in the neighborhood just at the water's edge, some of which are only seen at a very low stage of water. The fry will, therefore, find a suitable temperature in this part of the river. These, (say 25,000 fry,) with the 13,000 previously placed in a tributary of the Delaware, will, I trust, afford an opportunity to solve the problem whether the true salmon (*S. salar*) can be acclimated to this fine river.

THADDEUS NORRIS.

D—OHIO.

DEAR SIR: The salmon-eggs were put in the hatching-troughs at Castalia the 17th of March, and by the 1st of April 90 per cent. were out. Some of the eggs were developed 24 hours after reaching the spring. From the 1st of April to the 1st of May not over a hundred fish were lost. As they fed well at this time, the fish were placed, a few daily, in the large pond to care for themselves. This pond is of about 15 acres and contains an abundance of food; the usual temperature of the river is about 45° Fahrenheit; clear as crystal and deep, with shallow margins, on which numerous aquatic plants abound.

As there are no fishes inhabiting these waters, save small-sized species and the stickleback, I do not see but what the little salmon will have it their own way. There are at present about four thousand in the

pond. I do not think it worth while to send any more salmon-eggs to this State unless it be in the way of experiment, as this is the only water suited to their development. It discharges itself after a course of six miles into the Sandusky Bay, thence into Lake Erie. It has four dams in this short distance, and I doubt if a law could be passed at present to oblige the construction of fishways.

E. STERLING.

Professor S. F. BAIRD,
United States Commissioner of Fish and Fisheries.

E—WISCONSIN.

An arrangement was made with Mr. H. F. Dousman, of Waterville, Wis., to afford two troughs in his hatching-house for the care of the salmon-ova to be supplied for the State of Wisconsin. As the Eastern States had assumed the expense of the care of the eggs and the distribution of the young fish from the hatching-house to the waters in which they were to be placed, it was thought desirable that the Western States should show a like amount of public spirit, though they were not as well prepared, having neither fishery commissioners nor funds appropriated for the purpose of fish-hatching. Several gentlemen of Wisconsin were consulted by letter and in person, and a bill appropriating \$500 for the purpose was presented to the State legislature and passed, affording more than sufficient means to carry out the work for the season. Among those who were active in obtaining the appropriation were Dr. J. W. Hoyt, president of the Wisconsin Academy of Science and Art; Dr. I. A. Lapham, of Milwaukee; and Hon. L. J. Farwell, of Madison.

The first lot of spawn, 9,000 eggs, was received March 3, in very good condition, only 100 dead ones being found among them. A second lot came to hand on the 10th of the month, about 18,000 eggs, and with 350 dead ones. A third lot of 13,000 arrived March 19, with 1,000 of them dead. The spawn were received at Milwaukee and cared for between that place and Waterville, under the direction of Dr. I. A. Lapham.

Mr. Dousman was in correspondence with Mr. Atkins, of Bucksport, Me., with reference to the care of the eggs, and gave them his personal care and attention. On the 13th of March, the first young fish made its appearance, and before the last of the month all of the first lot were hatched. By the 1st of April, the second lot were also hatched, and within a few days all of the eggs remaining good were hatched.

Mr. Dousman started with 7,000 young fish on the 16th of April for the Menomonee River, and on the 17th turned them into the stream. They were put into the river at a rapids where the bottom was rocky, and which he deemed a favorable place for the young salmon.

This river was selected, after considerable discussion, as one of the more favorable streams on the Lake Michigan side of the State for the purpose. The Kewaunee River, of Kewaunee County, Wisconsin, was selected as another favorable stream, and on the 25th of the month Mr. Dousman started with all the remainder of the young fish, but 1,000, which were placed in Oconomowoc Lake.

A telegram from the steamboat agent announced the departure of a boat for Kewaunee the next day, and the young fish were brought into the city and put aboard the steamer. Before the steamer had left the dock, a stiff breeze from the eastward had closed the mouth of the river with floating ice, and all navigation from the port was stopped for several days.

In a letter of May 3, Mr. Dousman writes:

"The fish did very well until Sunday night, when they began to die, and on Monday morning about half of them were dead. I at once went to see Dr. Lapham, and we agreed that there was no use to try and get anywhere with them by rail, as they would probably all die, and the only chance to get any good out of them was to put them into the Milwaukee River.

"I accordingly took them up the river about five miles, to a very nice place in some rapids, and turned them loose.

"Those that were left seemed to be in very good condition and swam off quite lively.

The condition of navigation this spring was all that prevented a very gratifying success in the planting of salmon in the Wisconsin rivers; and although something may be expected from the few thousand fish put into these two streams, it would be advisable, if practicable, to make a larger experiment this fall.

APPENDIX C.

THE SHAD AND ALEWIFE.

(SPECIES OF CLUPEIDÆ.)

XV.—LETTERS REFERRING TO EXPERIMENTS OF W. C. DANIELL, M. D., IN INTRODUCING SHAD INTO THE ALABAMA RIVER.

DECATUR, GA., *January* 9, 1860.

DEAR SIR: Having some twelve years ago had, through the agency of my friend Major Cooper, the fecundated eggs of the white shad deposited in the Etowah River, one of the sources of the Alabama River, and that fish having been since taken in that river and in the Black Warrior for the first time, I desire to learn whether it has been through the agency of Major Cooper and myself. It seems that the white shad made its appearance one or two years after the deposit of the fecundated eggs by Major Cooper, if our memories as to dates be accurate. Please say what is the opinion of naturalists as to the time in which the fecundated egg reproduces itself. I suppose it is a difficult question. I am sure your courtesy will indulge this liberty. The solution given in Alabama to the appearance of the white shad in the Alabama, before advised of what we had attempted in Georgia for them, was that shad were taken by railroad from Savannah to Montgomery, some four hundred miles, and dressed in their hotels, whence the offal passed through gutters to the river, carrying the eggs of the fish. When it was established that the white shad had been taken in the Alabama and Black Warrior Rivers, a committee of the Agricultural Society of Alabama came to Georgia and took, in a hogshead of water, a number of the young shad and placed them in the Alabama River.

It is supposed by naturalists that the whale visits the inlets of South Carolina and Georgia annually to calve. That is my belief, based upon a number of facts which have reached me in the last thirty years.

Very respectfully and truly, your obedient servant,

W. C. DANIELL.

I inclose the letter of Maj. Mark A. Cooper, my assistant in introducing the fecundated eggs of the white shad into the Alabama River, through one of its main sources. Major Cooper corroborates the date, which is important to me, as I had in a letter to Col. Isaac Croom, Greensboro, Ala., said, on the recollection of a member of my family, that it was not later than 1850. That date has been since corrected by the recollections of Mrs. Daniell, and my youngest son, Charles, who were about at the date of my letter to Colonel Croom, and in their belief I firmly concur, from recollections recalled by them. I have corrected the error to Colonel Croom.

In the spring of 1858, after the presence of the white shad in the

waters of the Alabama, as Colonel Croom states from personal observation, at the falls of Black Warrior, near Tuscaloosa, several gentlemen went from Alabama to tide-water, in this State, and collecting a number of the fry of the white shad, transported them by railroad in a hogshead of water, kept cool with ice, to Montgomery, and committed them to the waters of the Alabama River. This, I believe, was done because having found that the water of the Gulf was suitable, a rapid increase of that fish was expected to be made.

Very truly, yours,

W. C. DANIELL.

Professor S. F. BAIRD,
Washington, D. C.

DECATUR, GA., *January* 20, 1860.

DEAR SIR: I thank you for your prompt response to my inquiry as to the time in which the shad attains its maturity. I take pleasure in supplying you with the information which you suggest relative to the introduction of the white shad into the Alabama River.

Learning from the fishermen frequenting the Savannah market during the season for taking shad, that there is a clear distinction between the shad of the Savannah River and those taken in the Ogeechee River, a neighboring stream, I drew the plain inference that the young fry of that fish attained their growth near the mouths of the respective rivers in which they had been spawned, and I supposed that if once placed in the Alabama waters they would thrive there as well as in the Atlantic rivers of Georgia.

In the early spring of 1848 I was with my family on my Drakies plantation, on the Georgia shore of the Savannah River, some ten miles above the city. My table was freely supplied with the white shad just taken and delivered alive at my kitchen. I had the matured eggs taken from the live parent spread on brown paper and the liquor pressed from the fresh milt of the male fish over the eggs. Thus prepared, they were dried in the shade and carefully laid aside. I sent the package to my friend Maj. Mark A. Cooper, of Etowah, Cass County, who carefully placed them in a small stream (branch) flowing into the Etowah River, as I had suggested. He paid frequent visits, and watched closely the deposit until all the eggs disappeared, which they did gradually. The Etowah River, as you know, is one of the upper sources of the Alabama River, taking its rise in Union County, and not very distant from the North Carolina line. I am dependent on the recollections of two members of my family for my date, (1848.) They have very distinct impressions, and have mentioned circumstances and little details, some of which I myself know to be true. As the winter of 1847–'48 was the last season that my family spent at Drakies, I cannot cite a more recent

date for the preparation of the shad-eggs. Possibly it may have been earlier.

The first white shad known to have been taken was in 1851 or 1852, in traps placed at the foot of the Black Warrior, near Tuscaloosa, Ala. Their value not being known, the owner of the traps threw some away and sold others for a few cents. About the same time the white shad was taken in traps at the foot of the falls of the Alabama River, near Wetumpka. In 1858 (or ten years, as I suppose, after the deposit of the eggs by Major Cooper) they were taken in abundance in the traps near Tuscaloosa.

Very truly yours,

W. C. DANIELL.

Professor S. F. BAIRD,
Washington, D. C.

ETOWAH, GA., *January* 26, 1860.

DEAR DOCTOR: I thank you for your letter of the 21st instant, received yesterday, calling to mind an incident of nearly twelve years past, which was an experiment made by me at your instance and request, with the expectation, as you advised me, of supplying the western waters emptying into the Gulf with the white shad, a fish unknown in those waters up to that date.

Mrs. Daniell, and Charlie, and you, are certainly just in their and your recollections. So is my recollection that early in the spring of 1848 I received of you by mail, directed to me at this place, a letter and a package. In your letter you stated to me a fact entirely new to me, but ascertained by naturalists, that the eggs of the white shad, taken from the fish as soon as caught, might be impregnated by a process artificial, preserved, and sent any reasonable distance, and, being favorably deposited at a proper period of the year, would hatch. You had therefore taken the proper steps to procure the eggs of the white shad thus prepared, and forwarded them to me, living on the Etowah River, the waters of which run into the Gulf of Mexico. You requested me to select a proper location in some small stream emptying into the Etowah. Your object, as you explained, was to stock the waters emptying into the Gulf with white shad, that the people of the States watered by these rivers might be furnished with one of the best that is known. The package which accompanied this letter contained the eggs, a great number. Being excited and interested, I took special care of the eggs, and in the month of April, selected, as I was advised by you, a favorable location in a small branch or streamlet which empties into the Etowah River near my residence, between the rolling-mill and flour-mill, and there deposited the eggs, taking every precaution to screen them against intrusion. After a time they disappeared, and there my account of the eggs must end. I did not take the precaution to confine them,

fearing that it might hazard success. I did not watch them by the hour; my business forbade it.

About two years thereafter I heard for the first time that this shad was found in our waters. I do not doubt that the introduction of this fish in our western waters is properly traceable to your enterprise and provident care.

Very truly yours,

MARK A. COOPER.

Dr. WILLIAM C. DANIELL,
Wayside, Ga.

XVI.—LETTERS REFERRING TO THE PRESENCE OF SHAD IN THE RIVERS TRIBUTARY TO THE GULF OF MEXICO.

GREENVILLE, ALA., *April* 11, 1872.

DEAR SIR: Your favor of the 4th instant to hand, and in reply state that the white shad are caught in Pea River, at Elba, Coffee County, Alabama. They commence catching them in fall traps about the 15th of March, up to the 1st of May. They commenced running in that stream about the year 1864, in small quantities, increasing in size and quantities every season. They also catch the hickory and gizzard shad, which are easily distinguished from the white, in size, flavor, and shape. The white shad's mouth comes together even, and is white. They are thicker and broader, have a dark streak on each side of the backbone after cutting open, and have a different flavor from any other fish, while the hickory shad's under lip is larger than the upper, and is black and extremely bony, and they taste entirely different from the white shad. Mr. John P. Reynolds, of this city, who was raised at Macon, Ga., and dealt in Savannah shad, was at Elba last week, and says they were then catching the genuine white shad.

Hoping that you may be able to stock the southern waters with them, and having no doubt that it can be done,

I am yours, respectfully,

JNO. T. KNIGHT.

Mr. W. P. YONGE,
Spring Villa, Ala.

P. S.—The above statement is correct.

JNO. P. REYNOLDS.

YONGESBOROUGH, ALA., *April* 15, 1872.

DEAR SIR: By request of Col. W. Penn Yonge, I address you in regard to the breeding and stocking of the southern waters with white shad and herring.

Several years' residence in South Alabama and Florida gave me opportunities of noticing the characteristics of many of the numerous streams giving their waters to the Gulf. I have fished, and hunted the deer, on the Conecuh and its tributaries, the Big and Little Escambias. Tide-water flows as high up as the Molino Mills, twenty-five miles above Pensacola, by railroad, giving at least seventy-five miles from the mouth of Escambia Bay, to the highest flow. I think I can safely say there are no streams on the continent better adapted for the introduction and reproduction of the shad and herring from the Atlantic. These waters

are pure, the bottom sandy and pebbly, affording ample and the best of spawning-grounds. The Alabama, Tombigbee, and Bigby, penetrating the northern limit of the State, are equally as well adapted for the purpose as any streams in the South.

For its central location, its proximity and facilities of transportation to the waters of Georgia, Alabama, and Mississippi, point to Colonel Yonge's place, Spring Villa, as the southern fish nursery.

I have seen a letter from J. T. Knight, of Greenville, Butler County, Alabama, stating that the genuine white shad has been taken out of Pea River, a tributary of the Conecuh. At Elba, Coffee County, Ala., Mr. W. R. Thugan says he has taken a few white shad at his mill this season, nine miles from Greenville, out of Pigeon Creek, another tributary of the Conecuh. Mr. J. P. Reynolds, a resident of Greenville, who was raised in Macon, Ga., and an old fish-dealer, on a recent visit to Alabama, saw the shad that was taken out of Pea River, and pronounced them the genuine white shad. If the above be a true statement, which I do not doubt, it is no longer an experiment, but a fact, that the shad can be introduced into the southern waters.

We are too poor to make it an individual enterprise. We want help.

Yours, most respectfully,

ISAAC W. POLLARD.

Hon. W. A. HANDLEY,
Washington City, D. C.

HOT SPRINGS, ARK., *August* 13, 1872.

DEAR SIR: In reply to the query contained in your letter just received, I have to reply that shad are caught in the Ouachita River, Hot Springs County, Arkansas. Ye lovers of choice fish; ye epicureans of Roman taste; just contemplate a fine, fat, delicate broiled, or a selected white shad, (*Alosa præstabilis*,) nicely "planked," served up for your breakfast, dinner, or at a picnic lunch, fresh from the pure, cool, bright waters of the Ouachita. Yes, we have annually a supply of shad, in April and May, found in this stream, near its mountain source, over one thousand miles from the mouth of the Mississippi River. They are caught in a trap constructed of boards, just below the dam. This dam is the first mechanical or physical barrier found on the Ouachita. It was built by the late William Farr, to supply water for a saw, grist, and carding mill erected in 1858.

The fish-trap was securely fastened to the bowlders and bed-rocks, in 1860, in effort to supply the Hot Springs market daily with fresh fish. After a spring-rain and a good rise in the water, we found, (April, 1861,) among a lot of black bass, salmon-trout, red horse, drum, and goggle-eyed perch, five fine large shad secured in the trap. Being familiar with the fish, I secured the lot and encouraged the attendants to save me all of

the "strange fish" that they caught. Every year since the trap was erected shad have been caught. This year we had a large increase; the first of the season was brought in April 5, and the heavy rains offered advantages for trapping. Shad continued running until May 12, 1872. Wagon-loads of them were brought to the springs during the season. I send you a photograph of one that measured $20\frac{3}{4}$ inches in length. I regret that it was not more artistically portrayed. I have partaken of shad caught in all the waters of the eastern States, or the rivers emptying into the Atlantic, from the Kennebec to the Savannah Rivers, but never enjoyed a finer-flavored or more delicious shad than those found in our waters. The river-bed, from the natural (novaculite) rocky abutment that partly crosses the Ouachita River, at Rockport, for a distance of some fifty miles above, is generally rocky, with several rapids, formed of metamorphic rocks, between that point and Farr's Dam. This rocky river-bed contains good, fresh, pure living water, that is mostly supplied from spring rivulets and mountains streams. After heavy or continuous rains, the main stream sometimes rises very high, frequently twenty to twenty-five feet in a few days. The Ouachita, (pronounced Oo-che-taw, generally Wash-e-taw,) is an Indian name signifying *male deer*, called thus in consequence of the famous hunting-grounds afforded in the mountain section of its source. It was, according to the old chart, published in 1784, called Ox River, but now it is known only by the name given to it by the aborigines. It rises in the western boundary of the State, between 34° and 35° north latitude, drains a fertile section of Arkansas and Lousiana; it empties into Black River; Black River into Red River; Red River into the Mississippi River, all between 31° and 32° north latitude.

In an article contributed to the "Turf, Field, and Farm," in 1869, I called the attention of ichthyologists to the fact that "white shad" existed in the Ouachita River. I feel that naturalists are not well versed or familiar with the true habits of the shad. I believe that shad can be found, at certain seasons, in most of the principal rivers on our eastern margin of the American continent, from the Saint Lawrence to the Rio Grande Rivers. Young shad, eleven inches long, were caught in the trap at Farr's Dam in November, 1871. I feel fully satisfied that this variety of fish is yearly becoming more abundant in the Ouachita River.

On the authority of Capt. Charles B. Church, of Memphis, Tenn., I will inform you of a little circumstance doubtless of interest to you. It is a matter of record, he states, that two fine large "white shad" were taken in 1834 or 1835 at the falls on the Ohio River, between New Albany, Ind., and Louisville, Ky. These falls are about one thousand four hundred miles from the mouth of the Mississippi River.

I have the honor to be yours, respectfully,

GEORGE W. LAWRENCE, M. D.

Hon. SPENCER F. BAIRD,

United States Commissioner Fish and Fisheries, Eastport, Me.

FORT SNELLING, MINN., *December* 26, 1872.

Your two letters of recent date came to hand in due season.

In your first letter you wish me to state as near as possible the date at which the fish in question were observed by me. It was during 1856 or '57, in May, I think about the middle of the month, as it was after the corn-planting of the farmers, and during the spring of the year in which our State legislature passed an enactment to prevent the taking of fishes with the seine, which of course thereafter prevented the presence of the fish from ever becoming generally known throughout the community. Since 1861, I have only been a visitor at Mount Carmel twice. Because of the prohibition of seining it is more than probable that the fact that the true shad ever has been, or is now, a visitor of Wabash River, is only known to a very limited number. The four I saw taken in the Neosho River were caught about the middle of May; one bit at a hook, another was accidentally hooked in the abdomen by my wife, and two others were secured by some seiners; and all were seen by me in 1871.

Then, again, if some fortunate individual should in some future time take some of the trout from Neosho River, it would not surprise me, for during the winter and spring of 1871 I procured from Livingston Stone some 1,200 trout-spawn, and hatched quite a number of them, and turned them into a spring branch, (emptying into Neosho River,) about one hundred yards from its mouth.

I am respectfully, yours,

WILL E. TURNER, M. D.,
Acting Assistant Surgeon, U. S. A., Fort Snelling, Minn.

SPENCER F. BAIRD,
Washington, D. C.

P. S.—By referring to Illinois State laws against seining fishes in the State, the exact date can be determined.

UNITED STATES ENGINEER'S OFFICE,
Mobile, Ala., February 26, 1873.

DEAR SIR: Your letter dated January 29 was received this morning, having been delayed many days in Georgia.

On our survey of Flint River, I made many inquiries in regard to the existence of the shad, but failed to establish any satisfactory evidence of their ever having appeared in its waters. Many of those from whom I sought information were fishermen who had been raised upon the coast of the Carolinas, and were perfectly familiar with the fish and the time of their appearance. They all said that none had ever been seen or caught by them.

The river has no obstructions, even at extreme low water, preventing their movements up or down. The river is a series of pools of comparatively deep water, discharging over gentle rapids formed by strata of

soft limestone, crossing the river at an angle of about thirty degrese with its direction. I found no difficulty in ascending these rapids at all times in the boats used upon the survey. On the banks of the river, from Albany down, are numerous large springs—some are 25 to 50 feet in depth. They actually swarm with fish—black bass, rock fish, perch, bream, &c. The water being perfectly transparent, every movement of the fish, and their species, are easily distinguished. All these springs have open outlets into Flint, and are just a little above the low-water surface of the river. To give you an idea of the large spring near Albany, it was discharging a volume of water 60 feet wide, 4 feet deep, mean velocity about 3½ feet per second. There are also numerous subterraneous streams emptying into the Flint.

I do not know to what cause to attribute the absence of the shad. Every portion of the river seems favorable for their propagation, and its large springs and tributaries safe depositories for their spawn. The waters of its tributaries, the Cookewahee, Kiokee, Nochway, and Spring Creek, are clear and deep, but highly impregnated with lime, so much so as to make the water unfit for use, but the impurities become completely neutralized by mixing with the Flint.

Very truly, your obedient servant,

HOLMES A. PATTISON.

XVII.—REPORT OF A RECONNAISSANCE OF THE SHAD-RIVERS SOUTH OF THE POTOMAC.

By H. C. Yarrow, M. D.

1.—INTRODUCTORY REMARKS.

Washington, D. C., *April* 17, 1873.

Sir: In accordance with your instructions, I submit the following as the result of my investigations in the States of Virginia, North and South Carolina, and Georgia in regard to the shad, herring, and rock fisheries, with a view to inquiring into the alleged decrease of these fish and the best methods of, and most favorable localities for, establishing hatching-houses for their artificial propagation.

Having received the necessary leave of absence through the courtesy of my commanding officer, Lieut. George M. Wheeler, of the United States Engineer Corps, I left Washington for Richmond, Va., on the night of the 2d instant, arriving in the latter city on the morning of the 3d.

At Richmond I visited the fish-market, but found only a few of the above-mentioned species of fish. The limited number of shad for sale commanded a price beyond the means of most persons. On inquiring the cause of this I learned that but a small number were now caught in the James River, and that for five years past the supply had been steadily decreasing, at the rate of probably 10 per cent. annually; that to such an extent had this decrease continued that but few fishermen were willing to risk their limited capital in an occupation promising such meager results. The cause of the decrease was variously stated. Traps, filth from the sewers of the city, constant fishing, and the plying of numerous steam-vessels are thought to drive the fish from their spawning beds.

The shad seen commanded a ready sale at from 65 cents to $1 per pair. At this time, April 3, the spawn was not within three weeks of being ripe. The first shad of the season were taken in the latter part of February. The fishermen, generally, expect the season to close about the last of May. Herring abounded in this market. They were from Pamlico and Albemarle Sounds. The price asked for them was from $4 @ $5 per 1,000. Some rock-fish were also seen which were taken near the city; these brought from 8 cents to 10 cents per pound.

2.—GREAT DECREASE OF FISH IN GEORGIA.

I next visited Augusta, Ga., where, according to all accounts, a most lamentable decrease in the supply of shad has existed for some time.

Mr. J. Higgs, of No. 8 Ellis street, an intelligent fisherman, informed me that it was his belief that there were not one-eighth as many shad in the Savannah River at the present time as formerly. He attributes the decrease to the numerous traps and nets used since the war, and the offal from the gas-works and paper-mills near the city of Savannah. He further informed me that shad running up the river and meeting, from the sources mentioned, impurities in the water, would retreat to Broad River, below the city. His statements were corroborated by Mr. Powell of the city marshal's office, and other persons of intelligence. I do not doubt the correctness of the views of Mr. Higgs to a certain extent, but consider the chief offending cause to be the numerous traps and nets which cover the face of the river from its mouth to Augusta. At this date there are perhaps 150 nets between Savannah and Augusta, while the average daily haul per net is not more than twenty shad.

By invitation, I visited Mr. Powell's fishery, and found it to be an admirable location for hatching purposes on account of the natural advantages surrounding it, and the fact that here more fish are taken than at any other point on the river, except, it may be, at the traps of Mr. Thos. Heckle, about five miles above the city. The nets used by Mr. Powell are of ordinary gilling twine, with 5½-inch mesh, and are 85 yards in length and 18 feet deep. When fished the nets are drifted a mile or so down the river at intervals during the day and night. Mr. Powell estimates the decrease in the supply of shad in the last five years at one-half, and considers 20 fish a fair daily average during the season. At this date, April 6, 24 hours' fishing with three nets has resulted in the capture of 74 shad. This, however, is far above the number ordinarily taken in the time mentioned. According to this gentleman, shad make their appearance in the Savannah near Augusta early in March. This year, however, owing to the backwardness of spring, they did not appear until three weeks later than the usual time. They are taken until late in May.

Mr. Thos. Heckle, who also owns a valuable fishery five miles above Augusta, as stated, does not use nets, but secures the shad by means of traps formed of stakes of wood. Mr. Heckle takes in these traps not more, perhaps, than ten fish per day on an average during the shad season; but notwithstanding the limited catch, I have no hesitation in recommending his fishery as favorable for a hatching-house, since in the traps the fish remain alive until the moment of their removal, whereas in the drift-nets they are frequently drowned, and thereby rendered useless so far as their spawn is concerned. Mr. Heckle informed me that he had fished the Savannah for a number of years, and that eight years ago 1,500 shad were taken at a single haul. At present a haul of over 40 seldom occurs. They sell readily at from 75 cents to $1.25 per pair, while formerly they brought but from 5 cents to 12 cents each. The shad-spawn will be ripe in about ten days hence.

Rock-fish are quite numerous in the Savannah River later in the season,

although they too have greatly decreased in numbers within the past few years. It is the impression among fishermen that they spawn as near the head-waters of the river as it is possible for them to get. Mr. Heckle earnestly recommends that the Commissioner of Fish and Fisheries authorize the introduction and reproduction of the red-bellied perch and bald-headed bream, common in this neighborhood, into more northern waters as well as into the waters of this vicinity. These fish, he informs me, are highly esteemed and readily command a high price. Some ten years since he placed a few bream in a pond on his plantation, which have increased a thousand fold, the species appearing to do quite as well in the sluggish water of the pond as in the rapid stream.

My next point was Columbia, South Carolina. In former years the Congaree and Wateree Rivers, near Columbia, were justly considered most excellent fishing-grounds for shad. Such, however, is not the case at the present time, nor has it been for several years past, not a sufficient number of shad being taken to warrant the expenditure of either time or money in their capture. A few are caught occasionally near the city in scoop-nets, but no regularly organized shad-fishing is carried on. It was impossible to ascertain the cause of the decrease. Rock-fish are still caught in these waters, but not to any great extent.

3.—DECREASE IN NORTH CAROLINA.

At Wilmington, N. C., the next place visited, I found the condition of affairs, with regard to the decrease of shad, to be about the same as that which existed at Columbia and Augusta. Owing to the peculiar character of the bottom and banks of the Cape Fear River, no seines are used in its waters for shad-fishing, the only means employed being drift-nets. Intelligent observers stated that the daily catch of this fish in the Cape Fear, between the mouth of the river and Fayetteville, is not at present more than 100 pairs. Here, ten years ago, shad sold at from eight to ten cents apiece; they now bring from 60 cents to \$1.25 a pair. The cause of the decrease could not be ascertained. I found but very few shad from the Cape Fear in the market. The fishermen informed me that five years since a haul of 150 pairs in a single day was quite a common occurrence; to-day they seldom take over 20 pairs. The first shad of the present season were two taken on the 28th of January; none, however, were subsequently seen until the 5th of February, when the number began to increase. At this date (April 8) the spawn is far from being ripe. The shad season closes here in the latter part of April.

In the Wilmington market I observed numbers of drum, trout, whiting, and herring from Masonboro' Sound. Herring, however, are not so abundant as formerly. The price they command at this point is from \$3 to \$5 per 1,000, though at the sound, seven miles distant, they

may be had for 50 cents per 1,000. They appear early in April, at which time the spawn is well advanced. I learned from the fishermen that it was the custom of the herring to deposit its eggs near the head-waters of rivers and creeks.

It may not be uninteresting to mention that, according to Mr. W. W. Nutt, of Wilmington, mackerel appeared in the Cape Fear River for the first time in the fall of 1872; but the people knowing nothing about them declined to use them as an article of food; bunches of from six to eight found few purchasers at twenty-five cents the bunch. Sturgeon are so numerous in the Cape Fear as almost to preclude the possibility of drift-fishing in the month of April.

I next proceeded to New Berne, N. C., which is situated at the confluence of the Trent and Neuse Rivers. The latter of these rivers has for years been celebrated not only for the fine quality of its shad, but for the very great number taken annually. In this river the decrease in the supply, if there is any, is hardly perceptible; although I was informed by trustworthy observers that, notwithstanding double the number of men are now engaged in fishing, no more fish are brought to market than was usual ten years ago; from which it might be inferred that the supply is not as great as formerly. Most of the fishing is by means of drift-nets, although a certain number of draw-seines are also employed. From what I could gather, Goose Island, a short distance above New Berne, is the locality affording the greatest number of fish. At this place Messrs. Pettiford, Brinson, Vincent, and others own extensive fisheries. These gentlemen estimated the daily catch as varying from 50 to 250 fish, 100 probably being a fair average. At this point there is a number of small islands, with narrow channels between, of a depth of 20 feet, wherein the shad appear to resort for the purpose of spawning, as their eggs are frequently found floating in the water, and, at this date, running out of the fish when netted.

Mr. Parish, who owns a fishery on the Trent, just opposite the city, (but whose specialty is herring-fishing,) caught 199 shad at one haul last year. Up to the present time, this year, his largest haul is 128. He uses a net 500 yards in length and 125 meshes deep, the meshes being 1¼ inches in size. The first shad of the season, in any number, at this point, were taken February 14, since which time the supply has been steadily increasing. The season will close the latter part of April. At the present time no fewer than 2,000 nets of different kinds are in operation between the mouth of the Neuse River and Goldsboro, N C., and if this industry is continued we must expect, in a short time, the same deplorable scarcity of shad here as in the rivers farther south.

Mr. B. B. Lane, another intelligent fisherman, and also for many years a dealer, informs me as follows:, "Shad generally make their first appearance in the Neuse in the middle of January, the first one of this year being caught January 9. During the present season, from the

latter date to April 10, six dealers have handled at New Berne alone no less than 75,000 shad by actual count. In addition there are some six or eight other dealers who probably, at a fair estimate, have handled 50,000 more, and if we take this number as indicating one-half the entire catch, we would have, in round numbers, the sum of 250,000 fish as the total catch in this vicinity for the period named." I am inclined to believe this a very moderate estimate for the Neuse, since many shad are taken at Kinston, Goldsborough, Smithfield, and other points on the river of which no account has been made, and I have no doubt that more than 500,000 shad are caught during the entire season in this river. The price of shad has varied very little in the last ten years, the retail price being about 70 and the wholesale 40 cents per pair. From this point shad are shipped in ice to all parts of the Southern States.

Although herring are still very numerous in the vicinity of New Berne, the general impression prevails that the supply has somewhat decreased within a few years. These fish appear to enter the river in three "washes," so called; the first and largest of which takes place about Easter Sunday. The largest single haul last year at the fishery of Mr. Parish was 29,800. He informs me that, at this date, he has taken at one haul over 20,000. Mr. B. B. Lane states, with regard to herring, that the six firms above alluded to have handled upward of 450,000 within the past ten days, and that the other dealers have probably handled 250,000; but that the total of these is but a small proportion of the whole number caught, as the citizens probably buy twice as many from the boatmen. He thinks that a million and a half have been taken during the period in question, and that a still greater number was taken in the same length of time last year. The largest single haul of herring ever made in this river was 41,000, by Mr. Brinson. These fish are seen as early as the middle of January, and disappear about the middle of May. In April the spawn are well advanced, and there is no doubt the fish run up the creeks and head-waters of rivers to deposit their eggs. The price of herring varies very little. They command at wholesale $3.50, and at retail, about $6, per 1,000. The prices are much lower than before the war.

Rock fish are quite numerous, and up to this time, about the 1st of January, some 3,000 have been handled by the dealers. It is thought they have decreased in numbers during the last five years. They are taken during nearly the entire year. They sell at from 8 to 10 cents per pound. Drum have also decreased, but for what reason is not known; probably cold winters, in which they perish in great numbers, may have an effect. At Kinston, on the North Carolina Railroad, some twenty miles above New Berne, a few shad have been taken, but not a sufficient number, however, to render their fishing remunerative. Seines and drift-nets are used here.

4.—CONTRIVANCES THAT CAPTURE ALL THE FISH.

At Goldsborough, also, on the Wilmington and Weldon Railroad, some thirty miles from New Berne, shad are taken, but in smaller quantities than at Kinston. At Smithfield, on the railroad leading to Raleigh, vast numbers of shad were taken in former years; now, however, but little fishing is carried on at this point. Just here, on the Neuse River, are a series of small falls, beyond which the fish seldom pass, although formerly numbers were taken within six miles of Raleigh.

At Rocky Mount, situated on the Tar River, on the railroad between Goldsborough and Weldon, Mr. Spicer owns quite an extensive shad-fishery, but the number of fish secured here in nowise compares with the number taken at the fisheries lower down the stream.

The next point of importance which I visited was Weldon, N. C. Here I had the good fortune to meet with Mr. John Emry, proprietor of the Emry House, mayor of the city, and controller of all the fisheries on this part of the Roanoke River. In this locality shad-fishing is carried on by means of scoop-nets and what are technically called "fish-slides." The scoop-nets, when in use, are allowed to trail in the rear of the boats, which are permitted to drift slowly down the stream. The fish-slides are solid and substantial structures, built of timber, and are placed in the strongest currents just below the falls at this point; these falls prevent the higher navigation of the river. The shad, seeking the head-waters of the stream, in endeavoring to find their way above the falls, get into the currents and are at once washed upon the screen of the slide, which slants upward from the bottom of the river. The force of the current effectually prevents their return. Owing to the ingenious construction of these traps, and the well-chosen positions in which they are placed, it is almost impossible for any fish to escape them, if seeking a higher part of the river.

Mr. Emry informed me that his average daily catch of shad for the season was perhaps 25 or 30. Commencing early in March, the season ends late in April. The number reported by Mr. Emry is, I believe, a low estimate, since I myself saw at a time when the shad were not "running" 15 taken upon the slide within two hours. It is his opinion that the supply has decreased in the Roanoke at least one-half in the last ten years, and, with due deference to his ingenious method of fishing, I must say that, in my opinion, if this plan is continued, shad will have disappeared almost entirely from these waters in a few years hence.

The price of shad varies very little at this point, 60 cents being about the average price per pair. The spawn of the shad will probably be ripe in about three weeks from this date, April 15.

Upon the slides are taken nearly every species of fish found in the Roanoke, sturgeon forming no inconsiderable item, while catfish, suckers, and rednose are captured in countless numbers. Later in the season the rock-fish resort to this locality in enormous numbers, and I am in-

formed that with two men constantly employed upon the slide to remove them, it is almost impossible to make room for the succeeding ones. Mr. Emry facetiously observed that should the commission desire the eggs of the rock, he could furnish a car-load in two weeks' time.

From Weldon I proceeded to Norfolk, Va., where the story heard so often within the past few days regarding the decrease in the supply of shad was repeated. Learning of no favorable localities in this neighborhood for the establishment of hatching-houses, I delayed only long enough to enable me to collect specimens of the food-fishes of the waters contiguous to the city.

From the testimony of the individuals I have mentioned, all more or less directly interested in shad-fishing, it is very evident that the supply of this fish has been steadily decreasing and continues to decrease year by year throughout southern waters; and further, it is my sincere belief that unless some means are employed to correct the state of affairs now existing in the sections visited, in a short time our tables will no longer be supplied with this delicate and highly-valued fish, whose advent in the spring is so eagerly anticipated.

As localities for hatching-houses, I have no hesitation in recommending Augusta, Ga., New Berne, N. C., and Weldon, N. C., since I am of the opinion that the ripe shad-spawn can be obtained in the best possible condition for propagating purposes at these points. I would also recommend that the Apalachicola, the Savannah, the Cape Fear, the Neuse, and the Roanoke Rivers be restocked with shad, close communication being made with all these streams by railroad.

In conclusion, I am happy in being able to state that at every place visited the greatest interest was manifested in the operations of the United States fish commission, while the hope was expressed on every hand that the enterprise about to be inaugurated throughout the South and West, in restocking the southern waters with food-fishes, might prove eminently successful.

H. C. YARROW,
Acting Assistant Surgeon, United States Army.

Prof. SPENCER F. BAIRD,
United States Commissioner of Fish and Fisheries,
Washington, D. C.

XVIII.—REPORT ON SHAD-HATCHING OPERATIONS.

A—OPERATIONS IN 1872.

MYSTIC BRIDGE, CONN., *July* 27, 1872.

SIR: Having received your order to stock rivers west of the Alleghanies with shad-fry, I left New London, July 1, at 2.45 p. m., accompanied by Aaron Anderson, foreman of the Poquonnoc Fish Company. Mr. E. S. Sanford, vice-president of the Adams Express Company, had very kindly furnished us with a letter of introduction to his messengers and agents, expressing his warm interest in the success of our enterprise, and requesting them to furnish us with all needed facilities for the safe transportation of the fry. This letter secured for us many favors, not only from his subordinates, but from all the companies through whose hands we passed. Many thanks are due to these companies and their messengers for their courtesies and timely aid.

We met Dr. William M. Hudson, of Hartford, chairman of the Connecticut fish commissioners, at Springfield, Mass., at 6 o'clock, *en route* for Hadley Falls, where we were to take in the fry. Dr. Hudson has taken the warmest interest in the project of stocking western waters with shad from its conception, and has done everything in his power to make it a success. The Connecticut commissioners have the use of the hatching-boxes of the Massachusetts commissioners, and their permission to use the shad-fishery for hatching purposes after the legal fishing is closed. Last year over 60,000,000 of shad-spawn were hatched at this place, and turned into the river. Mr. C. Smith, who has had charge of the hatching-boxes for several years, informed us that the shad were not only increasing in number, but in size. He had taken many shad this season weighing seven pounds, and upward. The season was a week or more later than last year, but there was every indication that the parent-fish would be more numerous, and a larger number of fry be turned into the river.

Our apparatus for transporting the fish was ten eight-gallon cans, furnished with handles, a large colander with very fine mesh, for the purpose of changing the water without disturbing the fry, a few water-pails, and a thermometer to gauge the temperature.

July 2.—We were up with the dawn preparing for our fish. The fry were taken directly from the hatching-boxes and put in the cans about two-thirds filled with river-water. The number of fry was estimated by Mr. Smith at 2,000,000. The thermometer stood at 78°, which indicated a continuance of the heated term which had prevailed for several days. We left the Holyoke Station at 6.22 a. m. The water was about 76°.

We took in ice at Springfield, and left for Albany at 9 o'clock. We reached Albany at 1.20 p. m., the thermometer indicating 96° in the shade. By occasional additions of ice-water the temperature in the cans had been kept down to about 76°. By way of experiment we took from the hatching-boxes a considerable number of ova not yet hatched, or just in the process of hatching, thinking they might bear transportation better than the fry. The loss was much greater among the ova than among the fry. Our cans were transferred to the Albany and Susquehanna road. We had a complete change of water at this point, and thorough cleansing of the cans by pouring the water from one can to another, and throwing away all sediment. We secured a fresh supply of ice, and left about 3 p. m. The water is very good along the line of this road, and we found no difficulty in making frequent changes, and in keeping the temperature down to 70°. At one watering-tank, near Binghamton, the water was at 55°, quite too cold for the fry.

July 3.—The fish passed the night safely. We reached Salamanca at 5.30 a. m. As the Alleghany River touches the railroad at this point, and this seemed to be the best place for stocking the Ohio, we left here three cans estimated to contain 400,000 fry, in charge of the ticket-master, who promised to see them immediately put into the river. The Erie trains form close connection here with the Atlantic and Great Western, and we left in a few minutes for Akron, Ohio, on our way to Indianapolis, where we had determined to make our next large deposit of fry. We reached Kent, Ohio, at 4.15, and as the Cuyahoga River was near the depot, we put in a few fry at this point. At Akron we were troubled to get good water. We drove a considerable distance to the canal, and secured enough to give the fry a change. The heat had reached 96° in the cars during the day, and the fish had suffered considerable loss.

July 4.—We reached Indianapolis a little too late for the last morning train to Saint Louis, and this involved a delay of ten hours. As the fry suffer much more in standing still than in transit, we concluded to make sure of a large stock in White River, and poured the contents of three cans into that stream, a little below the railroad bridge, in the suburbs of the city. We estimated the number at 400,000. We now had but a single can left and changed the water several times during the day. We determined to make an experiment with the remaining fry to see how far they could be carried. We thought if we could carry them across the plains and plant them in the Platte at Denver, it would be demonstrated that all the streams in the country can be furnished with shad fry. The experience would be worth all it cost, even if we failed. We left Indianapolis at 8 p. m., with fresh water and plenty of ice. The heated term had passed, which was very much in our favor.

July 5.—We left Saint Louis at 8.25 a. m., with a partial change of water and a fresh supply of ice. We took in a supply of Mississippi water from the hydrant, but it did not seem to agree with the fish so

well as the water we brought along from Indianapolis. The weather had grown cold during the night, and the water showed a temperature of 65°. This was cooler than suited the fry, and some of them perished. They grew more lively as the heat increased. At Washington and at Hermann, Mo., where the cars stopped a few minutes, we made small deposits of the fry, in the Missouri River. At Kansas City we found that we had ice and water enough to last another day in case we could not obtain it along the road. We left on the Kansas Pacific at 11.10 p. m., for Denver.

July 6.—We took in a fresh supply of ice at Brookville, and found good water at Wilson's Station, thirty-nine miles farther west. We now felt quite confident of getting some of the fry into the Platte in good condition. We are indebted to the officials of the Kansas Pacific Railroad for many courtesies.

July 7.—We met a train off the track about 7 in the morning, which delayed us over an hour. We reached Denver about 9.30 a. m., and in a few minutes had the joy of seeing Connecticut River shad swimming in the waters of the Platte. They were lively and headed up stream. We estimated the number of fry planted at this point at 2,000. As the Platte is fed by mountain streams full of trout, there can be little doubt that the fry will thrive in its waters.

I think the trip, so favorably ended, establishes the following conclusions:

1. Shad-fry in any desirable numbers can be planted in every barren stream in the country.

2. That all the larger branches of the Mississippi, the Missouri, and the Ohio Rivers can be stocked with shad next year at small expense.

3. That, as the numbers put into a stream in any shipment of fry depends upon its nearness to the source of supply, it would be desirable another season to hatch shad upon the Potomac, which is a days' journey nearer the west. From this point the distribution might begin as early as the first of June, to be followed by fish from the Hudson and the Connecticut Rivers later in the season.

Very respectfully, yours,

M. CLIFT.

Hon. SPENCER F. BAIRD,
United States Commissioner of Fisheries.

ROCHESTER, *July* 19, 1872.

DEAR SIR: My men have returned from Saint Paul. They had good luck, having placed about 25,000 young shad in the Mississippi River, two and a half miles above Saint Paul.

The shad put into the Alleghany River were deposited at Salamanca. Future observation must determine as to the return of any of these fish, though my experience assures me that they will come back if possible.

I have hatched 7,500,000 this year, and have put 200,000 above the Troy dam, in the Hudson; 50,000 in Oneida Lake, one of the tributaries of Oswego River that empties into Lake Ontario; 70,000 in Lake Champlain, which empties into the Saint Lawrence at Saint Ridges; and 50,000 in the Genesee River. The balance I placed in the Hudson.

Last year I put 15,000 young shad in the Genesee River, and now I can take at the mouth of the river, in Lake Ontario, twenty at a haul with a twenty-rod seine. These are over 7 inches long now, and we will see what we will see another year. I am very much interested in these experiments.

Yours,

SETH GREEN.

Prof. S. F. BAIRD,

United States Commissioner of Fish and Fisheries.

B—OPERATIONS IN 1873.

1.—THE SAVANNAH, NEUSE, AND ROANOKE RIVERS.

1873, *April* 20.—Arrived at Augusta, Ga.

April 21.—Went up the Savannah prospecting. Prospects very poor. Got back to Augusta at 4 p. m.; went down the river about four miles to a fishery. Two boats fishing; each boat caught one male fish.

April 22.—Went seven miles up the Savannah, from Augusta to Pitman's fishery; staid two days and two nights, and got no ripe fish; catching from three to eight fish a day.

April 24.—Moved three miles down the river, from Pitman's fishery, to Heckle's fishery; staid three days; caught no ripe shad; have not seen two shad alive at one time since we have been on the Savannah; shad selling for from 60 cents to $1.25 each in market.

April 28.—Received a telegram to go to New Berne, N. C.

April 29.—Arrived at New Berne, N. C.

April 30.—Spent the day getting ready to go up the Neuse River.

May 1.—Went up the Neuse fourteen miles above New Berne, to Cowpen's landing, at Vaughn's fishery; fished with seine at night; caught ten shad, none ripe, several of them spawned out.

May 2.—Caught five shad, none ripe. Temperature of water, a m., 64°; p. m., 65°.

May 3.—Caught eight shad, none ripe. Temperature of water, a. m., 68°; p. m., 67°.

May 4.—Caught twelve shad with seine, none ripe. Fished with skim-net along the shore; caught nine male shad. Temperature of water, a. m., 66°; p. m., 67°.

May 5.—Fished with skim-net; caught eight fish, two ripe; 50,000 spawn. River rising. Temperature of water, a. m., 62°; p. m., 65°.

May 6.—River rising. Could not haul seine. Caught three male shad with skim-net. Temperature of water, a. m., 63°; p. m., 64°.

May 7.—River reported rising. Forty miles up the river caught two shad with skim-net, both spawned out. Temperature of water, a. m., 63°; p. m. 63°.

May 8.—Water so high could not fish. Temperature of water, a. m., 63; p. m., 66°.

May 9.—River rising. No fishing. Temperature of water, a. m., 65°; p. m., 67°.

May 10.—River rising. No fishing. Temperature of water, a. m., 66° p. m., 66°.

May 11.—River rising. No fishing. Temperature of water, a. m. 66°; p. m., 67°. Spawn beginning to hatch in boxes.

May 12.—River raising, no prospects for more spawn. Temperature of water 65° a. m.; 67° p. m.

May 13.—Turned loose 45,000 young shad in Neuse River. Pitchkill, about twenty-four miles above New Berne on the Neuse, is the best place for shad-hatching that we could hear of.

May 14.—Received a dispatch to go to Weldon, N. C., on the Roanoke.

May 15.—Arrived at Weldon, N. C. They were catching some rock-fish, but no shad. The Roanoke very high but falling.

May 16.—Catching good many rock-fish. Shad do not run with rock. No chance of getting any shad till river falls.

May 19.—Got no ripe fish up to date. Got two ripe rock-fish; 110,000 spawn.

May 20.—River rising; no ripe fish. Temperature, of water a. m., 68°; p. m., 70°.

May 21.—River rising; caught no ripe fish. Temperature of water, a. m., 68°; p. m., 69°.

May 23.—River rising; caught no ripe fish. Turned loose 100,000 young rock-fish. Same principle hatches them that hatches shad.

May 24.—Fish slides all under water, but we caught no ripe fish.

May 25.—Caught a great many rock; none ripe.

May 29.—Did not catch any ripe fish up to date. River rising very fast. Took the 4 p. m. train to Washington.

May 31.—Went to the Rappahannock River from Washington. Shad fishing all done and nets hung up.

In order to build up the rivers that we operated upon there must be a close time of two days in each week before they can ever be restocked artificially, or in any other way. The lower end of the rivers are so completely barricaded with nets that the fish are nearly all caught before they get to the spawning grounds. The rivers are so nearly depopulated that there is scarcely any fishing done in the upper part of the rivers, and there would not be any done if it was not for the enormous prices they get for what few fish they do take.

SETH GREEN.

Table of shad-hatching operations at Augusta, Georgia, 1873, by Seth Green.

Date.	Temperature of water. A. M.	Temperature of water. P. M.	Fish taken.	Ripe fish.	Eggs taken.	Young fish turned into the river.	Remarks.
	°	°					
Apr. 21	....	....	2	....	....	....	
Apr. 22	....	....	3	....	....	....	
Apr. 23	....	....	8	....	....	....	
Apr. 24	....	....	....	....	....	....	
Apr. 28	....	....	....	....	....	....	Left Augusta for New Berne.

No ripe shad were taken. Shad were selling in market at from 60 cents to $1.25.

Table of shad-hatching operations at New Berne, N. C., 1873, by Seth Green.

Date.	Temperature of water. A. M.	Temperature of water. P. M.	Fish taken.	Ripe fish.	Eggs taken.	Young fish turned into the river.	Remarks.
	°	°					
May 1	....	....	10	....	....	....	
May 2	64	65	5	....	....	....	
May 3	68	67	8	....	....	....	
May 4	66	67	21	....	....	....	
May 5	62	63	8	2	50,000	....	
May 6	63	64	3	....	....	....	
May 7	63	63	2	....	....	....	River rising.
May 8	63	66	....	....	....	....	River too high for fishing.
May 9	65	67	....	....	....	....	Do.
May 10	66	66	....	....	....	....	Do.
May 11	66	67	....	....	....	....	River too high for fishing; spawn beginning to hatch.
May 12	65	67	....	....	....	....	River rising.
May 13	....	....	....	....	....	43,000	
May 14	....	....	....	....	....	....	Received dispatch to go to Weldon, N.C.
Average	64.6	65.6					

Table of shad-hatching operations at Weldon, N. C., 1873, by Seth Green.

Date.	Temperature of water. A. M.	Temperature of water. P. M.	Fish taken.	Ripe fish.	Eggs taken.	Young fish turned into the river.	Remarks.
	°	°					
May 15	....	....	....	....	....	....	Arrived at Weldon; river very high; no shad being taken, but some rock-fish.
May 16	....	....	....	....	....	....	No shad taken; water too high.
May 19	....	....	....	*2	110,000	....	
May 20	68	70	....	....	....	....	River rising.
May 21	68	69	....	....	....	....	
May 23	....	....	....	....	....	*100,000	Hatched same as shad.
May 24	....	....	....	....	....	....	Fish-slides under water.
May 25	....	....	....	....	....	....	Took many rock-fish not ripe.
May 29	....	....	....	....	....	....	Left for Washington, as the water was too high for fishing and no ripe shad had been taken.

* Rock-fish.

2.—THE DELAWARE RIVER.

BLOOMSBURY, N. J., *July* 12, 1873.

DEAR SIR: The undersigned having been honored by you with the appointment to the position of deputy United States commissioner for the purpose of collecting information concerning the food-fishes of the United States, and of superintending their transportation to western waters, would most respectfully submit the following report of his proceedings, reserving all observations and deductions for a future and more detailed report:

Your letter notifying me of my appointment was received on the evening of Monday, May 26, and I had the pleasure of reporting to you at Washington on the morning of May 28. At 11 p. m. of the same day I started for Weldon, N. C., where I arrived at 10 a. m. the following morning. Here I found Messrs. Holton and Green, who had for some time been endeavoring, though without success, to obtain ripe shad for the purpose of artificial impregnation. In this they had utterly failed from two causes, both entirely beyond their control. First, the method here employed in catching the fishes renders it almost impossible to obtain at the same time males and females in a ripe condition. The fishes are captured by means of a piece of apparatus called a slide, which is so arranged that in passing up stream the fish is caught by a rapid current and thrown upon a board platform, where it almost instantly dies. From all quarters I heard of the zeal and energy displayed by Messrs. Holton and Green in their efforts to obtain ripe shad, but spite of all their efforts they were entirely unsuccessful. However, important and interesting experiments were made with the rock-fish, and over one hundred thousand young were hatched and placed in the river. Secondly, as is well known, the Roanoke is liable to sudden and severe freshets; at the period of my visit the water of this river was about fifteen feet above its ordinary level, and residents of Weldon informed me that a few days previous it had risen 32 feet in twenty-four hours. As there seemed to be little use in retaining Messrs. Holton and Green at this point, I telegraphed you suggesting that they be at once recalled. On receiving a concurrent answer they at once set about their preparations for departure. On inquiry at the express-office it was found that the cost of forwarding the hatching-boxes would about equal their value, and upon Mr. Emry kindly offering to give them storage-room free until next season his kind offer was accepted.

Leaving Weldon at 4 p. m. we arrived in Washington the following day at 4.30 a. m., and I reported to you my arrival at 10 a. m.

Desiring to ascertain the condition of the shad in the river Delaware, I, at your request, telegraphed to the following persons, proprietors of fisheries on that river: B. P. Howell, M. D., Woodbury; A. J. Scarborough, Lambertsville; W. M. Hutchinson, Delaware Station. The answers received from all these persons showed conclusively that the sea-

son for ripe shad upon the Delaware River had not as yet arrived; Mr. Scarborough stating (which statement was afterwards shown to be correct) that but few ripe shad would be taken until after the close of the fishing season, (June 10.)

On the evening of May 28, accompanied by Mr. Holton, I started for Fredericksburgh, Pa., where we arrived at 3 a. m. We found the fishing season over, but obtained valuable and interesting information from Messrs. W. H. Smith and C. Rowley. No net-fishing is carried on at Fredericksburgh, and but few coarse fishes are taken at that point with the hook and line; in the lower portion of the river, however, large numbers of shad, sturgeon, rock-fishes, and herring are taken with seine, gill, and stake nets. The stake-nets are regarded as detrimental to the fishing interests, as many shad and herring escape from them severely injured and many taken are eaten by the eels, it frequently happening that hundreds of heads with back-bone attached are found in the nets of a morning. Mr. W. H. Smith has fished the river for the past eight years, his fishing-ground being some thirty-five miles below Fredericksburgh, within tide-water; he has taken during the past season about 3,000 shad and 6,000 herring, (alewives.) He estimates the number of shad sold in Fredericksburgh during the season at 10,500; this, however, is but a small portion of the catch. He commenced fishing about the 15th of March and finished May 20; during the last week of fishing noticed a number of ripe shad and frequently heard them "washing."

Mr. E. Rowley has fished for twenty years, except during the war. His fishery is located at Fallervale, twenty miles below Fredericksburgh. He corroborates the statements of Mr. Smith. Has noticed no ripe shad during the past season. Commenced fishing about March 20, and "hung up his net" May 26. There are no laws, as far as he is aware, regulating the fisheries of the Rappahannock. His fishery is a night-fishery, using a net 318 yards in length. Has heard shad "washing" in tide-water. Thinks the spawning season in this river is from April 15 to May 15.

We returned to Washington the same evening, arriving at 7.30 p. m.

On Monday, June 2, I visited the United States establishment for shad-hatching, situated at the lower end of Long bridge, operated by Messrs. Mason and Welsher. I found that during the past week very few ripe shad were met with, but that upon the afternoon of June 1 about 250,000 spawn had been taken. These, on examination of the boxes, showed to be in very fine condition, the percentage of unimpregnated spawn being very slight. A large number of spawn had been prematurely let loose by the breaking away, in consequence of a sudden storm, of a boom placed above the boxes for the purpose of breaking the force of the waves, which are sometimes so high as to upset the boxes. The fishing, June 1, commenced at 1.30 p. m., and continued until midnight. No ripe shad were taken after 9 p. m.

On the morning of Tuesday, June 3, I left Washington for Trenton, N. J., in company with Messrs. Holton and Green, having been ordered

by you to make a careful examination of the shad-fisheries of the Upper Delaware, and to find a suitable location for shad-hatching operations. We arrived at Trenton about 3 p. m. The next morning we visited Scudder's Falls, about seven miles north of Trenton. Through the courtesy of the Hon. Charles Hewitt, president of the Trenton Water-Power Company, we were enabled to make a thorough examination of the river at this point. Harvey's Island fishery has been fished during the present season by Mr. Aaron Pidcock. He reports the catch as very small, not more than half that of last year. He believed that the great run of shad had not as yet commenced; would be happy to give us every attention in his power, but believed that we would be able to do much better higher up the river. His fishery can only be operated in low water, and a rise of even a few feet would render it useless as a shad-hatching station.

Several days were now devoted to the examination of the fisheries in the vicinity of Lambertsville; over a dozen were examined, and finally it was decided to encamp at Lower Black's Eddy, situated in Bucks County, Pennsylvania, about twenty-six miles below Easton, and the same distance above Trenton. The fishery at this point is both a high and low water fishery, so that operations need not be suspended. A telegraph-station and post-office were within a short distance, and every facility, including free use of the nets and ground, was afforded by Mr. Samuel Farrel, proprietor of the fishing-grounds. The camp was named Camp Baird, in honor of yourself. The first spawn was taken June 12, the last June 27. We moved into camp June 14, and struck our tents June 29. For a detailed account of number of fishes captured and spawn taken, see the tabular statement. Being called to my home on June 20, I received yours of June 18, stating that you would be in New York City upon the following day. Wishing to obtain from you further orders, I repaired to New York, and received from you instructions concerning the transportation of spawn to the Monongahela River.

I returned to camp on Monday, June 23, and on the afternoon of June 24 started for Greensburgh with 15,000 young shad.

The following are my notes of the journey: Fishes shipped from Camp Baird at 5.30 p. m., temperature of air 64°, water 63°; reached Easton at 6.40 p. m., changed water; left Easton at 8 p. m, air 60°, water 63°; left Bethlehem at 8.40 p. m., air 60°, water 64°; left Allentown at 9.20 p. m., air 60°, water 63°; changed water; left Alliance at 10 p. m., air 60°, water 63°; left Reading at 10.30 p. m., air 68°, water 62½°; left Harrisburgh at 12.10 p. m., air 70°, water 64°; left Mifflin at 2 a. m., air 63°, water 60°; changed water; left Altoona at 5 a. m., air 66°, water 62°; left Blairsville at 7.08 a. m., air 67°, water 64°.

We arrived at Greensburgh at 8.15 a. m., and at once transferred the fishes to a small stream known as Jack's Run, situated upon the outskirts of the town. I was accompanied upon the trip by Mr. William Sewartz, of Point Pleasant, who afforded most valuable assistance. The

fishes reached their destination in good order, the low temperature of the night being greatly in their favor. Though furnished with an ample supply of ice, through the kindness of Mr. A. H. Lee, of Allentown, its use was not necessary, the temperature of the water never exceeding 65°.

I returned home via Pittsburgh, Harrisburgh, and Reading, arriving at camp June 28. Here I found all operations suspended. The erection of a dam by the Delaware and Raritan Canal Company at Bull's Island, with a chute of only 25 feet, had completely stopped the ascent of shad. A number of spent fishes upon their way down the river were taken, but the ascending spawners had disappeared. Upon my giving my assent, camp was broken June 29. Messrs. Holton and Green left for home on the following day. I remained until July 1, when I also left.

Such, sir, is a synopsis of my proceedings while in your employ. I have made numbers of observations upon the food-fishes of our rivers, which, with information obtained from various sources, I hope to present in a future supplementary report. A small collection of the fishes of the Delaware was obtained, and arrangements made for a more complete set.

I am, sir, respectfully yours,

J. H. SLACK, M. D.

Prof. S. F. BAIRD,
Portland, Me.

Report of shad and shad-spawn taken at Camp Baird, 1873.

Date.	Shad taken.	Ripe females.	Spawn taken.	Temperature of water. A. M.	Temperature of water. P. M.	Young shad turned into the river.	Remarks.
				°	°		
June 10	10	......	....	......	......	....	All males.
11	19	......	....	......	......	....	
12	15	1	15,000	......	......	....	
13	10	1	15,000	72	76	....	
14	7	2	35,000	72	74	....	
15	......	......	....	71	75	....	Sunday.
16	8	2	40,000	72	77	....	
17	21	2	25,000	74	80	....	
18	7	2	20,000	74	81	28,000	
19	12	4	65,000	76	83	....	
20	3	1	30,000	76	82	....	
21	17	5	105,000	75	81	35,000	
22	......	......	....	75	80	....	Sunday.
23	11	2	50,000	73	74	....	
24	1	......	....	72	72	....	Severe storm; 15,000 shipped.
25	7	2	35,000	70	77	30,000	
26	12	4	50,000	70	77	100,000	
27	9	1	10,000	72	79	....	
28	......	......	....	75	81	....	
29	......	......	....	76	77	140,000	Sunday.
30	......	......	....	......	......	100,000	
	169	29	495,000	73.2	78	433,000	
				75.6		15,000	
Total of young shad, including those put into Monongahela River						448,000	

REMARKS ON REPORT.

Percentage of loss, about 13 per cent.

Average temperatures: a. m., 73.2°; p. m., 78°; total average 75.6°. Percentage of ripe shad to fish taken, $17\frac{1}{6}$; average number of spawn per fish, 17,069.

3.—REPORT ON THE TRANSFER OF SHAD FROM THE HUDSON RIVER TO THE SACRAMENTO.

By Livingston Stone.

Charlestown, N. H., *December* 1, 1873.

Sir: I beg leave to present herewith a report of my operations in carrying live shad from the Hudson River to California, and in procuring the eggs of the Sacramento salmon for distribution into various waters of the United States.

I have the honor to be, your obedient servant,

LIVINGSTON STONE.

Hon. Spencer F. Baird,
United States Commissioner of Fish and Fisheries.

REPORT.

On the 9th of June, 1873, the day after the loss of the California aquarium car in the Elkhorn River, Nebraska, I received at Omaha a telegram from you, instructing me to return East with my men, and take a load of live shad to the Pacific coast. As soon as was practicable I reported to you at Washington, and immediately after began preparations for the overland journey with the shad. Your instructions were to procure the supply of shad from Mr. Monroe Green, at the New York State Hatching-Works, at Castleton, on the Hudson. Accordingly, when everything was ready I proceeded to Mr. Green's camp with my two assistants, Mr. Willard T. Perrin and Mr. Myron Green. Mr. Monroe Green had a sufficient number of shad on hand at the right age for the journey, and at about 5 o'clock on the afternoon of the 25th of June we left the shad-hatching camp for the Castleton railroad-station, with eight cans, containing in all eighty gallons of water and 40,000 shad. Mr. Welsher, of Seth Green's force, accompanied us as far as Omaha. We reached Albany safely, and left that city at 1.40 p. m., on the New York Central Railroad, going west.

In carrying live shad, it is considered necessary to give them a change of fresh water every two hours. We accordingly took on reserves of water, for the purpose of making these changes at Albany, Utica, Syracuse, Rochester, Buffalo, Dunkirk, Erie, Painesville, Cleveland, Illyria, Edgerton, Elkhart, and South Bend, arriving at Chicago Friday morning, June 27, with the fish in good order. The temperature of the water

when it was put into the cans was 70° Fahrenheit, and we kept it at about that temperature till we reached Chicago.

I ought to remark here that the main points in carrying living shad are: (1) To make constant and regular changes of water; (2) To keep the temperature even, not letting the water fall below 62°, or rise above 75°; (3) To avoid all sudden changes of temperature in the cans; (4) To avoid introducing impure, alkaline, or other unsafe water upon the fish.

I remarked that we kept the temperature of the water about 70° till we reached Chicago. The morning of our arrival here, however, was very hot, indeed, the thermometer indicated about 100° in the shade, and it was with great difficulty that the water could be kept down to a safe point without producing too sudden a change of temperature, but by making several changes in quick succession we succeeded in keeping the water from rising above 74°, and a little after noon left Chicago for Omaha, the fish being in good condition. From Chicago to Omaha we took on water at La Porte, Bellow's Station, Bureau, Tiskilwa, Rock Island, Davenport, Kellogg, Casey, and Avoca, reaching Omaha about noon.

During the previous night, on our way from Chicago, we had succeeded in bringing the water down to 68°, but before reaching Omaha it was again to 72°. Mr. Welsher left us at Omaha, and returned to Castleton, N. Y., his care and experience having contributed very much to the success of the expedition so far.

We left Omaha at 3 p. m., on the Union Pacific Railroad, the train being several hours behind time. The fish were still as fresh as when they left the Hudson. There were now but four days between us and the Sacramento, and we took courage. Owing to the scarcity of suitable water in the long reach of alkali country before us, I considered it necessary to take on larger reserves of water at the few places where the water could be depended upon. I accordingly procured at Omaha a thirty-gallon tank which had been recovered from the wreck of the aquarium car, and obtained permission from Mr. C. B. Havens, the train-dispatcher of the Union Pacific Railroad, to stop the train at the Elkhorn River, long enough to allow us to fill our tank from the Elkhorn. The water which we took from this river proved to be the best for the shad that we found on the road, although very roily and so hot (bringing the thermometer up to 84°) that it ate up our ice-supply very fast. About 8 o'clock Saturday evening we took on several hundred pounds of ice at Grand Island, Neb., but as we climbed the Rocky Mountains the air grew colder and we did not need much ice. During the night the temperature of the cans fell steadily till morning. Just before daylight we took on a small reserve of water at Big Spring, Neb. This water was cold and clear, and brought down the temperature of the shad still lower. At sunrise the thermometer indicated 67° to 68° in the cans, and remained at about that point till 6 o'clock Sunday afternoon, when we reached Laramie, and took on fifty gallons of Laramie River

water. The Laramie reserve had a temperature of 62°, and the night being very cold, the water in the cans dropped down to 66°. We built a hot fire, however, in the stove of the express car, and kept the temperature from going any lower. We obtained a small supply of water at Evanston, Utah, and as we descended Weber Cañon, approaching Ogden, the weather grew warm again, and the anxiety we felt about the water getting too cold was removed. We reached Ogden at 5.30 p. m., Monday, June 30, and laid in a large reserve of water from Weber River, which was very good, though roily. Here we left 5,000 of the shad in charge of Mr. Rockwood, of Salt Lake City, for the benefit of Great Salt Lake.

We had previously passed through very cold weather, and at Bryan, on the Rocky Mountains, there was even a slight flurry of snow, but on leaving Ogden Monday evening the air grew still colder, the temperature of the cans dropped to 65°, and there was no stove in the car to warm the air or heat water with. The air grew colder and colder, and it soon became obvious that some unusual means must be resorted to to keep up the temperature of the water in the cans. By telegraphing ahead for hot water, and by heating an iron in the engine furnace, and plunging it into a vessel of water, we managed, by incessant labor all night, to keep the cans from going below 62°, but it was a close struggle. The secret of the difficulty was, that the warm water which we obtained we could not depend on sufficiently to introduce it into the cans, and only ventured to utilize its heat by placing a smaller vessel of good water in the large pail of hot water, and letting it remain till it became warm. Daylight and the warmer atmosphere that followed were never more welcome than they were on Tuesday morning as we emerged into them, finding ourselves about fifty miles over the Nevada line, with the shad in fine order, and now only five hundred and fifty miles from Sacramento. We had been changing the water a little oftener than every two hours night and day up to this time. We now began to change the water almost every hour, and felt quite hopeful of success. By utilizing the hot water which we obtained in various ways, and by constant exertion, we were enabled from this time to keep the temperature of the cans at a safe distance from the minimum limit of safety, and taking on another large reserve, both of hot and cold water, at Humboldt, at 7 o'clock Tuesday evening, July 1, we passed the night safely, and found ourselves the next morning within the limits of California, on the western slope of the Sierra Nevada, with all the shad in first-rate condition, and only seven hours' run to Sacramento City. At 9 o'clock Wednesday morning we took on a small supply of water at Alta, Cal., and reached Sacramento City four hours and a half afterward, with the shad as fresh and lively as when they were taken from the shad-hatching boxes on the Hudson. At Sacramento City we met S. R. Throckmorton, esq., chairman of the California State fish commission, and Mr. John G. Woodbury, the State fish-warden, who expressed themselves wholly satisfied with the appearance of the young fish. We

took on 30 gallons of Sacramento River water here, and a large supply of ice, and at twenty minutes past two we left Sacramento, on the California Pacific Railroad, which runs up the Sacramento Valley, for Tehama, where it was thought best to deposit the shad. We reached Tehama just after dark, and at ten minutes past nine on Wednesday evening, July 2, 1873, we placed our 35,000 shad in the Sacramento River, near the village of Tehama, just above the railroad bridge, in the presence of Mr. Woodbury and several citizens of Tehama, the whole expedition, from beginning to end, having been an entire success.

Below will be found a list of the places where we procured supplies of water, and also a table indicating the changes of temperature in the water which contained the shad.

We took on water east of Omaha, at Albany, Utica, Syracuse, Rochester, Buffalo, Dunkirk, Erie, Painesville, Cleveland, Illyria, (well-water,) Edgerton, Elkhart, South Bend, (bad lime-water,) Chicago, (Rock Island Railroad depot,) La Porte, Bellow's Station, Bureau, (rain-water,) Tiskilwa, (spring-water,) Rock Island, (good,) Davenport, (from Mississippi River,) Kellogg, Carey, Avoca.

West of Omaha we took on water at—

	Gallons.	Temperature.	Character of water.
Elkhorn River	50	84° F.	Roily.
Big Spring	10	58° F.	Clear.
Laramie River	50	62° F.	Clear.
Evanston, (spring-water)	10	57° F.	Clear.
Ogden, (Weber River)	50	60° F.	Roily.
Humboldt Station, (spring-water)	50	65° F.	Clear.
Alta	20	60° F.	Clear.
Sacramento	20	Warm.	Muddy.

The temperature of the cans was as follows:

Hudson River water, 70°.

Albany to Chicago, 70°, 74°.

Chicago to Omaha, 74°, 68°, 72°.

Omaha to Laramie, 72°, 70°, 69°, 67°.

Laramie to Ogden, 67°, 66°.

Ogden to Humboldt, 66°, 62°, 66°, 70°.

Humboldt to Sacramento, 70°, 68°, 66°, 67°.

Sacramento to Tehama, 67°, 70°.

Sacramento River water at Tehama, 74°.

In concluding this account of the journey with the shad, I will say that the water was changed every one or two hours, night and day, from 6 o'clock p. m. on Wednesday, June 25, to 9 o'clock p. m. on Wednesday, July 2, being about 105 times for each of the eight cans, or equivalent to changing the water of one can 840 times.

I will also add that a careful estimate was made of the number of shad that died on the way, and it was found to be about 400, or 1 per cent. of the whole.

4.—ON SHAD-HATCHING OPERATIONS BY THE COMMISSIONERS OF THE STATE OF MAINE.

BANGOR, ME., *August* 6, 1873.

DEAR SIR: You ask me for data, particulars, &c., of our shad-hatching experience this year. The awakened interest in fish-culture in our State has made such calls upon our time, has kept us so continually occupied, that we were able to make but little anticipatory preparation before we were called to the field of operation. Our experiments were not rich in results of great numbers of fish, but in valuable experience for our future guidance not contained in any of our books on pisciculture. We were governed in our time of commencing by the operations of the Massachusetts commissioners at Andover, as from them we were to learn the mode of procedure. This necessarily delayed our operations at Bowdoinham until the 15th June. Further delays in obtaining the requisite material for boxes, the changes required by practical use making all those constructed useless in waters where there was no current, consumed so much time that when all was ready the season was passed, and none but spawned shad could be obtained. The opinion was arrived at that all the shad required as spawners could be obtained at Bowdoinham between the 10th and last of June. The great obstacle presented in the path of progress to every attempt to bring about rapidly the restoration of fish to our waters, is the system of patenting every result of simple experience in practical work, and thus establishing a toll on every road to success. Conclusions as obvious and unavoidable as that "twice 2 is 4" have been the subject of claims for letters-patent until one can scarce use a bit of charcoal as a disinfectant lest he be inextricably involved in a lawsuit, upon the claim that the wood was only charred and not carbonized.

If this was exhibited only in placing a moderate royalty on every mode, or article, or implement, so patented, the tax would be readily paid; but, as in our case, the demand is now so exorbitant as to amount to prohibition. The sum demanded of us for one of these patents was two-thirds of the entire appropriation of the State of Maine for our whole department. We succeeded, most fortunately, in constructing a hatching-box that, while it infringed upon no patent, gave all the requisite motion of the eggs in the box, so necessary to the successful hatching of shad-spawn in a *current*. At Bowdoinham there was no current to move the eggs in the boxes; the short, chopping wave at the ebb and flow of the tide gave simply an up-and-down motion, while the wind with its added force projected the waves into our boxes and washed out the eggs. A new form of box was adopted, a simple parallelogram, with a bottom of wire netting. The boxes were floated within a plank frame as a sort of breakwater; this was a success, so far as hatching was concerned, but the mesh of the wire netting was too large, and our fish escaped as fast as hatched. This brought us to the end of the season, as no more shad that had not spawned were to be had. The num-

ber of shad hatched, according to an estimate made by Mr. Commissioner Stanley, and coincided with by his assistant, Mr. Brown, was 100,000. The United States commissioner, Professor Baird, afterward very opportunely supplied us with 100,000 shad-fry from Hadley Falls, on the Connecticut, which were planted in the Penobscot at Mattawamkeag. The possibility of obtaining shad-spawn from Massachusetts so much later in the season than with us, would seem to indicate that the habits of the shad are the reverse of the salmon. The earliest spawning of the salmon is at the head-waters of the river, the latest run of fish always spawning lower down the river. Our inference here may not be correctly deduced, as our experiments were at the mouth of the Kennebec, where the fish are probably turned back from their native spawning-grounds by the Sprague's Dam at Augusta, and cannot follow out their instincts. The shad at Topsham, also, were found all spawned. These later fish never could have ascended much higher than Brunswick, owing to the natural obstructions in the river.

E. M. STILWELL.

XIX.—REPORT ON THE PROPAGATION OF THE SHAD (ALOSA SAPIDISSIMA) AND ITS INTRODUCTION INTO NEW WATERS BY THE U. S. FISH COMMISSIONER IN 1873.

By James W. Milner.

1.—SHAD-HATCHING AN IMPORTANT DISCOVERY.

In the progress of fish-culture there has probably been no more difficult problem carried forward to a certain and successful conclusion in a short space of time than the propagation of shad, nor has the propagation of any species afforded more efficient results in the attempt to increase the numbers of the food-fishes.

2.—PLAN OF OPERATIONS.

The plan of the work of shad-hatching, under the appropriation for that purpose, as established by Professor Baird, was to begin as far south as the Savannah River, early in the season, and visit the rivers northward as the season advanced, it being a well known fact that the shad enter rivers in succession to the northward, at intervals of a few weeks, for the purpose of spawning. The Savannah River, of Georgia, and the Neuse and Roanoke Rivers, of North Carolina, on the representation of Dr. H. C. Yarrow, who investigated the southern streams, were selected, and the locations of the hatching-stations determined, with reference to the supply of fish obtained at the fisheries, and the facilities for transferring the young shad by rail to waters destitute of this species of fish. The intention of the work was not only to multiply numbers in the streams where the spawning fish were taken, but to stock other waters with this valuable fish where they had been exterminated or where they had never existed. The Potomac and Delaware Rivers, the Susquehanna and the Rappahannock Rivers, were kept in view as favorable streams for shad-hatching, with possibly one or two rivers still farther north late in the season, from which contributions could be made to the waters of the Mississippi Valley and the great lakes.

It was determined by the commissioner to obtain if possible the services of Seth Green, and arrangements were made with him for that purpose to afford to the commission his own aid and as many of his trained experts as could be spared for the season.

3.—OPERATIONS ON THE SAVANNAH, NEUSE, AND ROANOKE RIVERS.

On the 17th of April Seth Green, with a party of four, his son, Mr. Holton, Mr. Welsher, and Mr. Mason, all having had ample experience

in the work of shad-hatching, arrived in Washington, and Mr. Green, after learning the plans and intentions of the commission, left, accompanied by the whole party, for Augusta, Ga., where the first station was to be established.

The intense heat affecting Mr. Green unfavorably, he was obliged to return home, and the work fell to the hands of the rest of the party to perform.

Mr. Mason reports that a visit to the fish-markets on the 21st found only twenty shad offered for sale, and on visiting the fishing-grounds the fishermen asserted they did not think fifty shad would be taken in one day within ten miles of Augusta. Remaining at the fisheries until 11 p. m., only one shad was caught, though six drift-nets were in use on that portion of the river which he visited.

Until the 28th, the time was spent in visiting the different fisheries above and below Augusta, for a distance of twenty miles along the river, with no better results. From sixteen trap-nets in a rapid portion of the river he saw four shad taken, all dead from the rapid water crowding them against the lower side of the crib.

On the 28th, receiving advice from Mr. Welsher, who had gone north prospecting on the Neuse River, the camp on the Savannah was abandoned and the whole party proceeded north to New Berne, N. C., and on May 1st selected a location for a hatching-station fourteen miles up the river. At this place from eight to fourteen shad were taken nightly until the 6th, when the rains had raised the water in the rivers until the only fishing possible was with skim-nets. Two spawners were taken on the 5th with skim-nets, from which 45,000 eggs were taken and impregnated.

The river continued to rise until, on the 12th, the party were driven from their camping ground and returned to New Berne. The young shad were hatched with scarcely any loss of eggs, and were turned into the river, with the exception of about one hundred, carried to New Berne for exhibition.

On the 15th, orders having arrived from Washington, the party divided, Mr. Holton and Mr. Chester Green going to the Roanoke River and selecting a locality for a hatching-station near Weldon, N. C., and Messrs. Mason and Welsher came to Washington.

Messrs. Holton and Green at this point were so fortunate as to obtain and impregnate a quantity of spawn of the striped-bass or rock-fish, *Roccus lineatus*, which they placed in hatching-boxes and treated them in the same manner as shad ova and succeeded perfectly in bringing them to maturity in about the same period of time required for shad.

4.—OPERATIONS ON THE POTOMAC RIVER.

On the 16th the station on the Potomac River was established at the south end of Long Bridge, at Jackson Tavern, Virginia. Messrs. Knight and Gibson, owners of extensive fisheries in the vicinity of Washington, and owning the fishery at that point, afforded a supply of spawning shad

and extended many valuable favors through their foreman, Captain Evans, who was always ready to afford assistance.

On the night of the 17th twenty ripe spawners were taken and about 400,000 eggs impregnated and placed in the hatching-boxes. This large quantity afforded us anticipations of a more than ordinary success on the Potomac River, that were not destined to be fulfilled.

On the 18th about five hundred shad were taken at the fishery, and only two ripe spawners found among them, affording about 50,000 eggs. The temperature of the river on this day was 63° in the morning and 67° in the afternoon.

On the 19th about six hundred shad were hauled in the seines, among which ten ripe fish were found and about 250,000 ova impregnated. The temperature at 6 a. m. was 62°; at 6 p. m. it was 65°.

On the 20th, one hundred and twenty shad were taken, seven ripe fish found, and 120,000 ova obtained.

The 21st was cold and rainy. In the night-hauls six hundred shad were captured, seven ripe fish handled, and 150,000 spawn taken.

The night-catch of the 22d was one hundred and thirty shad, four ripe fish and 100,000 spawn.

The 23d saw the first young shad out of the egg, about one hundred and forty hours after the first eggs were impregnated, the water having varied in temperature between 62° and 67°, the time being just about double that occupied when the temperature ranges from 75° to 80°, in both instances the water remaining quiet. On this day four spawners were found and about 90,000 eggs obtained.

Arrangements were made with fishermen on the river, at Mr. Livingston Stone's request, for obtaining one thousand young cat-fish and five hundred yellow perch to be forwarded to the California aquarium car. The fisherman collected the perch, *Perca flavescens*, in a live box, and a number of cat-fish, *Amiurus albidus*, were also obtained.

On the 24th 50,000 eggs were put into the boxes.

On the 25th 400 shad were taken, three ripe fish, and about 60,000 eggs taken. Twelve boxes of the young fry were turned loose in the river, about 200,000 shad.

On the 26th, from a catch of about 200 shad, four ripe ones were obtained and about 75,000 eggs impregnated. There were also on this day about 220,000 young fish turned loose in the river.

On the 27th a heavy storm from the north broke the connecting links of the boom that had been arranged to protect the boxes, and sweeping it down upon some of them, released about 275,000 young shad into the river, with the eggs in the same boxes remaining unhatched, of which there was a small percentage just ready to hatch, and many of them, no doubt, emerged from the egg in good condition on the bottom of the river.

Out of 250 fish four ripe fish were taken and 80,000 spawn put into the boxes.

On the 28th about 155,000 young shad were put into the river, and 60,000 eggs impregnated from three spawners.

On the 29th the river was muddy and the water high from rains to the northward, and but few shad were taken in the nets, and no spawners found among them. The temperature of the river on the afternoon of the 28th reached 70°, and on the 29th varied from morning to evening from 70° to 75°.

On the 30th no ripe fishes were taken. The temperature of the river varied from 75° to as high as 80°. About 50,000 young shad were turned loose into the river.

On the 31st the temperature of the water had fallen as low as 62° in the morning, but rose again before night to 70°. Day-time fishing for spawners, though rarely successful, afforded this day three ripe fishes, and at night nine more were taken, and from all 250,000 ova were obtained.

June 1, no ova were obtained.

On June 2, 214 fishes were captured and five ripe fishes handled, producing 100,000 spawn, the temperature of the river varying between 68° and 72°.

On the 3d the fishermen made twelve hauls of the seine, capturing about 200 shad, among which were found four spawners, and 80,000 eggs taken from them.

On the 4th twelve hauls were made and but few shad taken. Eight ripe females were obtained in the evening, and 190,000 eggs impregnated.

The 5th saw but few shad taken at the hatching-station. More than 100,000 young fish were turned out of the boxes; four ripe females were obtained and about 70,000 eggs impregnated. The river for the first time during the season showed a temperature as high as 84°.

On the 6th the fishermen made twelve hauls, taking only ninety shad; eight of them were ripe females, but the eggs were all found to be dead, on extrusion, with a white speck in the normally uniform yellow tint of each egg, showing its addled condition. The temperature of the river in the morning and the evening was 78° and 84°. As dead eggs are seldom or never taken from the shad except in a time of high temperature of the river, this condition is without doubt to be attributed to this cause. There were about 75,000 young fish turned loose on this day.

On the 7th nine hauls were made, two ripe spawners obtained, and 15,000 eggs impregnated. There were about 125,000 young fish turned into the river. The highest record of the thermometer in the river on this day was 80°.

Knight & Gibson stopped fishing for the season on this ground, "cut out the nets," as it is termed on the river, their fisheries farther down the river having been stopped several days before, and it was with difficulty and additional expense the gang of men could be kept together

for the sake of procuring spawners, the proprietors of the fisheries being partially remunerated for their expenses during this additional time.

A new and less expensive seine was put in on the 8th, but no shad were taken in it, and but few other fishes, which was no doubt partly owing to the bad construction of the seine. About 20,000 shad were turned into the river.

On the 10th a new seine was set at work on the ground, and making eight hauls one shad was captured. The temperature of the water was 80° to 82°.

It was now decided to break up the station, and the boxes, chains, anchors, and boat were stored away until another year.

N. W. Clark, of Clarkston, a fish-culturist of Michigan, arrived in Washington on the 4th, sent out by the State commission for a supply of shad for waters in Michigan. A sufficient supply for this purpose was in readiness, and it was decided at the same time to move a shipment out to the head-waters of the Kanawha River, in West Virginia. Six large milk-cans, with a capacity of fifty quarts each, had been provided for the purpose, but at the request of a prominent fish-culturist two large galvanized-iron cans, with a very convenient and ingenious device for aeration, were substituted for two of the milk-cans. About 50,000 young shad were put into the six cans. The water from the river at 5.45 p. m., the time when the fish were put into the cans, was 83.5° in temperature, and a quantity of ice was immediately procured for the purpose of reducing this high degree of heat, as it was much too high for the young fish to endure.

The ice placed around the cans while being transferred in a wagon from the hatching-station to the ferry-boat of the Orange, Alexandria and Manassas Railroad, reduced the heat somewhat, and while crossing the river on the steamer a small quantity of ice was put inside of the cans, so that at 8 p. m., when the train left Alexandria, two hours and fifteen minutes after the fish had been put into the cans, the temperature was reduced to 72°.

A reserve can of water, obtained at a hydrant in Alexandria, was taken on board the train and a quantity of ice put into it.

Fresh water was obtained at Warrenton Junction, at Staunton, and North Mountain Summit, always from the railroad-tanks, as no other water was to be obtained; the temperature of the water in the reserve can was reduced with ice to about 52° to 53° before it was put upon the fish, and the cans of fish held a very uniform temperature throughout the journey of from 68° to 73.5°.

In the night it was discovered that a large number of the fish in the galvanized-iron cans were dead, though those in the tin cans seemed to be all lively and in good condition, and in the morning very few living ones could be found in the galvanized-iron cans.

At 8.30 a. m. of the 6th, Ronceverte, West Virginia, the point on the

Greenbrier River selected for placing the fish, was reached. There had been fresh water afforded the cans five times, and the aerating apparatus applied seventeen times.

The temperature of the Greenbrier River was found to be 76°; the water in the cans from 72° to 74°, a difference too slight to injure the young shad. Procuring a boat, some time was expended in finding a spot free from minnows and small fishes; but they were finally turned into a quiet inlet to one side from the rapid current of the river.

The two cans of galvanized iron did not contain a single live fish, but the loss in the tin cans was very small. The process to which the sheet-iron is subjected while the zinc coating is applied had possibly left sufficient injurious matter on the metal, which had not been well cleaned and produced the fatal effect upon the fish; and, though large fish may not be materially affected by the use of this metal, it is not advisable to use it in the transportation of so delicate a creature as the young shad is.

Out of the *50,000 estimated to be the number that left Washington, about 30,000 were put into the river alive.

On the 9th 40,000 shad were put into the tin cans and sent to the New River, Virginia, headwaters of the Kanawha River, in the charge of Mr. Welsher.

The temperature of the water was reduced to about 70° before the cans were put into the wagon. Leaving the city at 7 p. m. they reached Central Station Virginia, at 10.30 a. m. of the 10th and were moved to the river in an ox-cart and turned out of the cans in good condition with an imperceptible loss.

The work of the season had resulted in the releasing of 1,370,000 young shad in the Potomac River, and about 90,000 contributed to the headwaters of the Kanawha River as a portion of the stocking of the waters of the Mississippi River tributaries, which was a part of Professor Baird's plan for the season's work.

The conservatism which Seth Green had taught his men, in estimating numbers of eggs, is to be taken into account, when comparing the success of the season with that of other localities; as the uncertain and unreliable method in estimating in different parts of the country have resulted in very different standards, by which the approximations to the true number have been attained.

In the future it will be advisable to begin operations earlier, as it is not probable, in ordinary seasons, that the temperature of the water will continue cold so late in the spring, and the last of April, or possibly the middle of the month, might find occasionally a fish spawning; and the true policy in effecting large results is not to allow a single spawning of eggs to escape the vigilance of the operators.

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*The standard for estimation of numbers of the live fish adopted by Mr. Green's men, with commendable desire not to exaggerate, I suspected from the first to be too small, as it would not account for the estimated number of eggs in the boxes. A test was subsequently made as related on page 443, and any excess of numbers in this report over former published statements in the newspapers is to be attributed to this fact.

Shad-hatching on the Potomac River, Jackson City, Va., opposite Washington, D. C., in the year 1873.

Date.	Number of shad taken.	Number of spawners stripped.	Number of ova.	Temperature of water. 6 *a.m.*	6 *p.m.*	Period of development.	Number of fish released in Potomac River.	Number of fish transerred to distant rivers.
May 17	....	20	400,000	......	65°	About 7 days ...	....	
18	500	2	50,000	63° to	67°	....do	....	
19	600	10	250,000	62°	66°	....do	....	
20	Morning and evening. 270	7	120,000	62°	64°	About 6 days ...	....	
21	Evening tide. 600	7	150,000	*d*62°	66°	....do	....	
22	Evening tide. 130	4	100,000	62°	63°	About 5 days ...	....	
23	Few.	4	90,000	62°	65°	*f*About 4 days...	....	
24	Evening tide	....	50,000	65°	68°	....do	....	
25	Morning and evening. 400	*a*3	60,000	66°	69°	....do	200,000 220,000	
26	200	4	75,000	66°	69°	About 3 days ...		
27	250	4	80,000	*e*63°	67°	... do	275,000	
28	150	3	60,000	65°	70°	About 70 hours .	155,000	
29	None.	....	....	70°	75°	....	100,000	
30	None.	....	....	75°	80°	....	50,000	
31	....	*b*12	250,000	70°	72°	....	50,000	
June 1	....	....	....	......	......	....	....	
2	214	5	100,000	68°	72°	About 3 days ...	....	
3	200	4	80,000	68°	73°	....do	....	
4	Few.	8	170,000	70°	75°	About 70 hours .	....	
5	Few.	4	70,000	72°	84°	....do	100,000	*g*50,000
6	90	*c*8	....	78°	84°	....	75,000	
7	....	2	15,000	77°	80°	About 70 hours .	125,000	
8	None	....	....	75°	78°	....	20,000	
9	....	....	....	......	......	....	....	*h*40,000
10	....	....	....	80°	82°	....	....	
	Total.... 3,665	111	2,170,000	68°.2	71°.9		1,370,000	90,000

Percentage of eggs hatched .... .67¼

a One spawner in day time.
b Three spawners in day time.
c Eggs all dead.
d Cloudy and rainy.
e Heavy storm from north.
f First shad hatched on 23d, six days.
g Transferred to Greenbrier River, W. Va.
h Transferred to New River, Va.

5.—METHODS EMPLOYED IN SHAD HATCHING.

Up to 1867 the speckled trout, (*Salmo fontinalis*,) the salmon, (*Salmo salar*,) were the only fishes that had been hatched on any considerable scale in the United States. Experiments had heen made with more or less success on the yellow perch, (*Perca flavescens*) and the wall-eyed pike, (*Stizostedium americanum*,) the common sucker (*Catostomus communis*,) the corporal,* (*Semotilus corporalis*,?) the salmon-trout, (*Salmo namaycush*,) and the white-fish, (*Coregonus albus*.)†

At the invitation of the States bordering on the Connecticut River, Seth Green visited the river and selected what afterward proved to be a most excellent locality for a shad-hatching station. He began his experiments in shad-hatching by using the usual methods for trout-hatching—the

* A Treatise on the Artificial Culture of certain kinds of Fish, &c., by Theodatus Garlick, M. D., Cleveland, Ohio, 1857, p. 137.

† Annual Report Department of Agriculture, 1859.

ordinary troughs, with a gravel covering on the bottom, and a stream running with a slight current over the gravel. Owing to the very light specific gravity of shad-eggs, it was soon found that there was no success whatever to be hoped for by these devices.

Several experiments of different devices were attempted before the mode now adopted was tried and proved successful. But a successful method was discovered and employed sufficiently long before the end of the season to hatch out a large quantity of shad, and the results were apparent to the fishermen of the river three years afterward.

The apparatus* devised by Mr. Green was merely a light pine box, 22 inches long, 15 inches wide, and 12 inches deep; the bottom was of wire-cloth—about twenty wires to the inch. It was used without a cover. On the ends of the box two pieces of two by four scantling were nailed diagonally to the lines of the box, so that floating in the water it was slightly tilted, the side of the box sunk to the least depth being up stream, so that the wire-screen bottom was presented to the current at a slight angle, sufficient to produce a circulation of the water inside of the box that kept the light shad-eggs in gentle motion. In a sluggish tide-current the floats are usually nailed on so that from the upper edge of the box to the top of the float in front there is a distance of 5 inches, and from the upper edge of the box to the top of the float behind there is 2½ inches. The angle of the floats is of course less for a more rapid current, the object being to produce a current that will move the eggs as gently as possible, a more rapid motion being regarded as injurious, especially in the later stages of development, when it materially hastens the rupture of the shell membrane and effects a too premature birth The wire-screen bottom is coated with coal-tar, or what is better, asphaltum varnish, both for the purpose of preserving the wire-cloth and for a supposed effect in retarding confervoid growth.

The boxes are connected by bridles and lines in gangs of six, and to the first box an anchor-line with a large stone at the end holds the gang in its place in the river. The box next the anchor has the floats extending both ways beyond the box about 8 inches, but on the remaining ones they are sawed off flush with the box.

The method employed at the station at Washington is as follows: The fish are taken in a seine one thousand fathoms long. As soon as the bag of the seine comes near the shore the fishermen, gathering the lead-line and cork-line in their hands, gradually work it up to the top of the water, shaking the fish into the bunt of the bag. A boat is brought alongside and the fish thrown into it with a scoop-net, the shad being at once separated from the other species. The operators, provided with ordinary six-quart milk pans, containing about three-fourths of an inch of water in the bottoms, are in the boat and, taking up the shad one by one, detect at once, by a gentle pressure on the belly of the fish, if the spawn is ripe by its free emission from the

* See illustration at end of volume.

oviducts. In an unripe one the eggs will not flow at all, and if the eggs are only nearly ready, the extrusion is difficult and in masses and the fish is rejected. When a female is found from which the eggs flow in a liquid stream when a gentle pressure is applied, it is carefully taken in the hands of the operator, the left hand applied closely around the tail and the head of the fish crowded against his body, while with the right hand a slight pressure is applied with the thumb and finger to the abdomen of the fish, and a stripping movement executed which causes the eggs to flow rapidly into the pan. As soon as it is evident that the spawn is all obtained, the shad is thrown into the basket, it being impossible to preserve the lives of so delicate a fish even if the utmost care is taken in handling it. But though they are delicate in this particular, and have a very slight tenacity of life when taken from the water, they are a very muscular fish. Experts in fish-culture who have handled the white-fish and salmon-trout of the lakes, regard them much stronger than the same sized fishes of either of the latter species, and if the utmost pains is not taken to prevent their releasing themselves from the hold, they will flounder and splash in the pan of eggs and probably throw a large proportion out, and damage some of those that remain.

In stripping down the abdomen, a great many scales will be removed from the sides of the fish. These, if carelessly allowed to fall into the pan, will be an annoyance, as the eggs will adhere to them. They can be gathered and thrown away, by an adroit movement of the hand, with a little experience, without making any delay in the operation of stripping the fish.

Mr. Green estimates the number of ova taken from an average spawner at about 20,000 eggs, and rarely estimates above 28,000 for the most prolific shad. Mr C. C. Smith, operating for the Connecticut State commission, estimates an average good spawner at 50,000 ova. We have not made a test of these estimates, and are not prepared to offer an opinion with reference to the disagreement.

The salmon family contains the species that had, previous to 1867, been dealt with in fish-culture on any considerable scale in the United States, nor had any of the family of fishes that embrace the shad, the *Clupeidæ*, been experimented with in Europe.

The conditions that necessitated new methods in the shad-hatching from that of the trout and salmon were not only in the less specific gravity of the shad ova, but in the very much less period of time required for the development of the fish from the egg. With the trout, at the ordinary temperature of spring-water, about 47°, the trout-eggs remain in the hatching-troughs from seventy to one hundred days; with the salmon in some hatching establishments, where the water assumes a winter temperature of 35° or 36°, the fish are not hatched out under about five months from the time the eggs are impregnated. The shad, when the temperature of the water was as low as from 62° to 67°, only re-

quired about six days to emerge from the egg, while in a temperature between 75° and 80° only about seventy hours or three days from the time the eggs were impregnated, the fish were numerous in the boxes.

This fact was, of course, a great advantage over the trout, both in the very much less amount of labor in the care of the ova and in the fact that, being in the always precarious egg-stage for such an inconsiderable length of time, they suffered a proportionately less amount of exposure to the ills and damages the longer-developing *Salmonidæ* were subject to.

The eggs of the shad are somewhat smaller than those of the white-fish, (*Coregonus albus*, Les.,) which are smaller than in the trout, (*Salmo fontinalis*,) and much smaller than in the salmon, (*S. salar.*) The eggs, just after impregnation, of the white-fish are a little less than one-eighth of an inch in diameter, while those of the shad are but about one-tenth. The shell membrane is also thinner and the egg more delicate, and does not seem to endure the handling and ladling out into moss or cups for transportation, or even into the hatching-boxes. Experiments in the transportation of shad-eggs, even for short distances, have proved failures, while the white-fish eggs have been sent from Michigan to California, being on the road ten days, and have arrived in good condition, and trout-eggs and salmon-eggs have been shipped much farther, the latter from England to Australia and Tasmania.

A small percentage of loss occurs in the boxes of shads' eggs, and by careful fish-culturists the dead eggs, detected at once by their white hue, are removed; but by many are not interfered with, as they are usually too few to occasion very serious damage to the good ones.

The tool used for their removal is not the egg-tongs or forceps used in trout-culture, but a small net, of minute mesh, less than one-half inch extension measurement, mounted taut on a square frame of wire, about 3 inches square, and the bad eggs are floated up to the surface and thrown out with the *scaff-net*, the good ones passing through the meshes more readily than the bad ones, covered with the mossy parasitic growth that so soon develops upon dead eggs.

Unlike the fishes of the salmon family, the shad, instead of dropping the ripe eggs into the open cavity of the abdomen to pass backward and out through an ovipore, has a continuation of the oviduct to the outside, the two ovaries in their posterior prolongations uniting into an oviduct, in which, by dissection, the eggs can be seen to pass within the transparent membrane of its walls to its outlet.

6.—RELATION OF THE TEMPERATURE OF THE WATER TO THE PROPAGATION OF THE SHAD.

Temperature of the water of the sea, rivers, and lakes has a very important relation to the increase of the food-fishes, influencing the time of the spawning migration, the development of the eggs, and the wel-

fare of the young fishes. The eggs, not only after they are deposited and impregnated, but before they leave the body of the fish, are affected by the temperature of the water. The spawning season of the shad seems to be regulated by the increase of temperature as warm weather advances. Their migrations on the coast are in quite a regular succession of time with relation to latitude. From letters received, from published statements, tables of inspection, and personal observation, the periods of their migrations are nearly as given in the following: They make their first appearance in the Saint John's River, Florida, the 1st of December. The season of their greatest numbers is February, and they disappear in April. In the Savannah River, Georgia, it is much the same. On the coast of North Carolina* they make their first appearance in December, their greatest abundance is in March, and they disappear in May. In the Neuse River, North Carolina, the periods of these stages of their migration are a little later. In the Potomac River the advance individuals are found in February; they are found most numerous in April, and they disappear early in July. They are found in the Delaware River at first in March; in the Hudson River early in April. In the Connecticut River they are first found in the last of April, are the most abundant the last of May, and do not leave the river until late in July. In the Kennebec River, Maine, they are first taken in April, and have left by the middle of July; and the same dates apply to the Androscoggin River. In the Saint John River of New Brunswick† they appear about the middle of May, and in the Miramichi River of the Gulf of Saint Lawrence late in May.

But not only in the ordinary times of ascent is there evidence of their sensibility to the temperature of the water, but in late seasons, when the snow-water from the northern sources of the streams keeps the water cold for a longer period than usual, the shad are retarded in their ascent of the rivers, and are taken in quantities by the nets near the mouths of the rivers, while the fishermen above wait impatiently for the run up stream that they know to be prevented by the coldness of the water; even an entire failure in the shad-fisheries in Albert County, New Brunswick, was attributed by the fisheries overseer to the extreme lateness of the warm weather of spring.

Among the *Salmonidæ* of the great lakes the salmon-trout, (*Salmo namaycush*, Penn.,) the white-fish, (*Coregonus albus*, Les.,) and the black-fin, (*Coregonus nigripinnis*, Gill.,) avoiding high temperatures, remain in the deep waters during the warm weather, but in early winter are taken abundantly in the shoaler water near the shores. The antipathy to warm water varies to some extent, the white-fish showing the least, and the black-fin the most, sensitiveness to the warmth.

The transportation of young fishes in cans indicates this peculiarity also. The *Salmonidæ* will thrive in a temperature as low as 40°, and

* See Notes on the Shad, &c., by H. C. Yarrow, M. D., p. 452.

† Article on the Shad and Gaspereau, &c., by Charles Lanman, p. 460.

show no symptoms of lethargy in water kept at 45°, while the shad are most active between 68° and 72°, and become torpid and sluggish at a temperature below 65°.

In the case of the shad there are many indications that the development of the spawn within the ovaries is hastened by the heat and retarded by the cold. In a warm season ripe spawners are more numerous early in the season than in a cold one, and the period for obtaining them is apt to close earlier.

A temperature in the water of about 75° or 76° seems to be the most favorable for obtaining and hatching spawn. At 80° the eggs hatch very rapidly, but the young fish do not do so well, and a more serious difficulty is the fact that many spawners are taken with the eggs dead in the ovaries; that is, they have lost entirely the capacity for fecundation, and as there has been no instance of this kind reported when the water was below this temperature, it is probably correct to attribute the cause to the high temperature of the water.

The temperature of the water regulates the period of development of all fishes' eggs that have been experimented with. In the shad-eggs the period required for release of the fish from the eggs was, with an average temperature of 64°, though actually varying between 62° and 68°, about seven days. With an average temperature of about 65°, actually between 62° and 69°, the time was about six days. With an average temperature of nearly 66°, actually between 62° and 69°, the time for the most of the fish to be free was about five days. An average of 68°, between 66° and 75°, released them in about three days. An average of 72°, really between 65° and 80°, released the fish in about seventy hours, the shortest time observed for a large quantity of eggs, though usually some were hatched a few hours before the majority, and a few eggs lingered for several hours after the *eclosion* of the rest.

7.—THE OVARIES AND OVA OF THE SHAD.

The ovaries of the shad are familiar to eaters of shad-roe, as they are usually cooked whole. They differ from those of the white-fish (*Coregonus albus*) in being shorter in proportion to their length, and the membrane of the ovaries is thicker and stronger, while the white-fish, unlike the shad, has the entire length of each divided transversely into folds, which, on removing the outer membrane, are found to hang suspended from the long thickened fold of the membrane on the dorsal side of the ovary, an arrangement that facilitates the passage of the eggs toward the walls of the ovaries, before they fall into the cavity of the abdomen.

The eggs remain in a compact solid mass until they ripen. At first minute, and the ovaries occupying but a small space in the abdomen, they gradually increase until the whole abdomen is distended with their bulk. On a close examination, as they approach the time of spawning, there will be found the maturing eggs, the larger, which are rather

uniform in size, and others of variable size. Whether the latter are the forming eggs for the next year, for two or three succeeding years, or for the lifetime of the fish, has not been determined. In a spent-fish, with the ovaries shrunken and small, they are still found full of these eggs of different sizes; and numerous specimens of this character were preserved in alcohol while at Topsham, Maine, at the close of the spawning-season.

Several weeks before the time of spawning the ovaries have grown so as to fill the cavity of the abdomen, though still increasing. A short time before spawning, transparent eggs of large size, contrasting strongly with the golden hue of less mature ones, will be found scattered through the still compact mass of ova. These become more and more numerous, and after a time the compact condition becomes less apparent and the eggs fall apart and separate, and the extrusion begins, a liquid stream of eggs and mûcous flowing from the oviduct on the slightest pressure of the abdomen. After they lose their compact condition they are no longer preserved for cooking.

Unripe eggs, on extrusion, instead of flowing in a liquid stream, come away with difficulty in clotted masses, and generally with a little blood. The same thing will be observed on stripping a fish, with ripe eggs, too long, as the eggs of the season are not all ripe at once, as is frequently seen in dissecting the ovaries of spawning-fish.

The fish, after the spawn is taken away, has a soft and flaccid appearance about the abdomen, which, after natural spawning, becomes contracted and drawn up, tapering slenderly toward the tail, the familiar appearance that characterizes the despised "spent shad."

The eggs covering thickly the bottom of a pan containing water are not easily discernible, as they are so very transparent; and as they come from the fish are so soft and light that when the fingers are moved among them there is nothing other than the water apparent to the touch, and in the dark a person trying the experiment would be willing to admit that there was nothing in the pan but water.

8.—THE MALE FISH.

The male fish resembles the female so closely that there is very little certainty in attempting to distinguish between them by outward form, even when the comparison is to be made with a gravid female. The males are ordinarily rather smaller than a full-sized female, and the sex is quickly known, when ripe, by the flow of the milt from the spermaries. Of course dissection always reveals the sex, though the spermaries even in the height of the spawning-season are not nearly so large in proportion to the size of the fish as in most fishes handled by fish culturists.

In large lots of shad brought in by the fish-boats early in the season, ripe "milters" are often very numerous when as yet a ripe "spawner" is very rare, while later in the season the ripe males and females are not found in equal numbers, and it is not a seldom occurrence to have

a fine lot of spawn in the pans and not a single ripe male to be found to fertilize it with, and it has, to the great disappointment of the breeder, to be thrown away as worthless. This scarcity of ripe males, late in the season, may possibly be attributed to this fact, that many of them ripen so much earlier in the season than the females.

The amount of milt that can be expressed at one time is limited to a small quantity, but a very small quantity will impregnate a very large number of eggs, and it is asserted by some to be the more successful way, though usually the milt of a large number is made use of when available. Under the microscope the milt is seen to be thronged with myriads of spermatozoa. In impregnating by the dry method their strong impulse for movement is observed, by placing a small quantity of the milt on one side of a quantity of eggs covering the bottom of a pan, when, if left to itself but a short time, it will be found to have diffused itself between and among all the eggs. If but one of the spermatozoa is needed to fertilize each egg, but a very small quantity of the milt is required.

9.—THE IMPREGNATION OF SHAD EGGS.

The ova from the female being collected in the pan with a small quantity of water, a slight pressure on the ripe male near the anal opening will force out two or three jets of the milt, which, falling into the pan, is stirred by a gentle movement of the hand with the fingers spread, care being taken to keep the fingers from contact with the sides or bottom of the pan, as in that case some of the eggs would be crushed The milt being diffused throughout the water, the pan is left for a few moments to allow the spermatozoa to come in contact with the eggs. The pan should then be filled full of fresh water, and gently swayed until the water charged with milt is thoroughly mixed with the fresh water and the eggs slightly rinsed, when soon afterward the water may be poured nearly off and the pan refilled with fresh water, and after a slight and always gentle rinsing up of the eggs, the pan may be allowed to stand for several minutes.

The fact has been referred to that the eggs were not discernible to the touch when put into the pan, nor is there any change in this particular, if no milt is added; at any rate, for the length of time that the eggs have been observed in this condition, a half hour or more. For about twelve or thirteen minutes, when the temperature of the water was about 70°, after the milt was added, no change was observed, but about this time a careful movement of the fingers in the pan discerned their presence, and in a little more than twenty minutes from the time the milt was applied they were felt like shot against the fingers, and to an experienced eye were observed to have increased slightly in size.* This

* Dr. E. M. Schaeffer, of the United States Army Medical Museum, while making investigations with the microscope at the station, found that the increase in size was nearly nine-twentieths of their original diameter in one hour and fifteen minutes after contact with the milt.

stage of their condition is known to fish-breeders as the "spawn-rising," referring to the greater bulk in the pan from the increase in size of each egg. The increase in size and hardness continues for several minutes, during which the water is poured off and fresh water poured into the pan two or three times, and the eggs gently stirred with the fingers. In pouring in the water the edge of the dipper is placed against the sides of the pan and the stream directed between the eggs and the sides of the pan, as it is likely to damage the eggs if poured directly down upon them.

In the white-fish eggs it was observed that before impregnation an egg placed upon a hard substance was easily crushed by a slight pressure of the finger, but after impregnation the shell membrane became so tough and turgid that a very strong pressure with the finger failed to break it.

The assertion is made by nearly all experienced in shad-breeding, that there is a considerable fall in the temperature of the water in the pan containing eggs during impregnation; some of them judge from the sense of touch, and others have made the test with a thermometer, the amount of reduction claimed being from six to ten degrees. Having made this test with a thermometer on several occasions, I have to say that it never resulted for me, though on one occasion a very large number of eggs were in the pan. The temperature in the pan was 69° when the milt was applied, and the thermometer was put into the pan and the bulb immersed and allowed to remain, showing not the least change, though every phenomenon of impregnation occurred. When the changes of water were made the thermometer was each time inserted, but showed the same temperature as the river, the test being continued nearly one hour.

10.—THE SUSQUEHANNA, DELAWARE, AND HUDSON RIVERS.

On the Delaware River, hatching operations were begun by Dr. J. H. Slack, with Mr. Holton and Chester Green, at Lambertsville, N. J., on June 12, and continued until June 27, resulting in the placing of 433,000 young shad in the Delaware and 15,000 in the Monongahela, at Greensburgh, Pa.

The hatching-station at Washington was broken up on the 11th of June, and the same evening, accompanied by Mr. Welsher, on his way to Marietta, Pa., to work in connection with the Pennsylvania commissioners, and Mr. Mason, we went north to find a later migration of the shad.

At Newport, the Pennsylvania commissioners, operating with one of Mr. Green's men, had obtained up to date forty-three spawners, out of a little more than one thousand shad taken, and producing, according to Mr. Boehm's notes, 1,500,000 eggs. A greater success would have resulted if there had been a reguar fishery established at this point.

We soon ascertained that there was not much prospect of procuring shad for transfer westward, and took the next train for Albany, N. Y.

We arrived at Castleton, N. Y., ten miles below Albany, on the afternoon of the 13th. The shad-hatching station of the New York commissioners is situated on the Hudson River nearly opposite this place, a few miles above Coeyman's Landing. Taking a boat, we crossed to Camp Green, and met a hearty reception from Mr. Monroe A. Green, to whose efficient management the responsibilities of this successful establishment are delegated by the superintendent, Seth Green.

The force to whom continual employment is afforded during the shad season is six or seven men at the fishery and five to seven men in the direct work of the hatching-station.

There were one hundred and twenty-two boxes, containing about two millions of eggs and young shad, anchored in a quiet channel of the river between an island and the west shore. Four boxes of young eels, (*Anguilla bostoniensis*,) of about 4 inches length, gathered from the river, were retained for transfer to distant waters, a large number having been provided the unfortunate California aquarium car.

They were at present obtaining from five to twenty spawners per day, and had taken the first spawner of the season the 25th of May, though they had been on the ground several days. The water on the 25th had a temperature of 56°; on to-day it was 78°.

Questioning Mr. Green for some exact data for results from his own personal knowledge in the improvement in the numbers of shad in the river, the following facts were developed: The first year spawners were scarce, and even fewer the succeeding years until the fourth year, when they began to feel the benefit of their own work in the marked increase of fish, and the spawners their special desideratum. Double the number of hatching-boxes were required for the accommodation of the increased quantity of ova. He remarked that, taking the standard now used in estimating the number of eggs, the correct estimate of the number hatched the first year would be about 7,000,000.

11.—JOURNAL OF A TRIP WITH SHAD AND EELS TO CALUMET RIVER, ILLINOIS.

At 6 p. m. the same evening the young fish were put into the cans; six fifty-quart cans, containing 70,000 shad, and one can containing 4,000 eels, with a reserve-can for fresh water, were put into a boat and carried across to Castleton, to be shipped upon a train passing at 9.12 p. m.

On arriving at the east bank of the river the cans of fish remained at the water's edge until about half an hour before the train arrived, when one pailful, 12 quarts, of fresh water was afforded each can; the temperature of the river-water being 75°, and the air rather cooler.

The point determined upon for this first "planting" of shad in the Great Lakes was the Calumet River of Illinois, at South Chicago, on the Lake Shore and Michigan Southern Railway.

The cans were put into the baggage-car of the passenger-train, Mr. Mason remaining with them until their arrival in Albany, at 9.40 p. m.,

where they were put out and moved upon a truck to the penstock at the depot baggage-room, to await the 1.45 a. m. train, which afforded the best connections through to Chicago.

The temperature in the cans was 70°, and in the fresh water from the penstock 68°. Fresh water was supplied each can twice while waiting between the trains, about twelve quarts each time.

The cans were put into the baggage-car, Mr. Mason in charge of them, and fresh water was again afforded them from the reserve-can at about 4 a. m. At 5.15 a. m. the reserve-can was filled at Utica, and fresh water again supplied before reaching Syracuse, at 7 a. m. After leaving Syracuse, a partial change of water was afforded and fresh water again taken on board at Port Byron at 8.10 a. m.

The thermometer indicating 64° in cans, and the reserve-can showing a temperature of 60°, fresh water was again supplied, and at Palmyra, at 9.20 a. m., the reserve-can filled with water from the well at the depot, having a temperature of 50°. This, more than ten degrees of difference, necessitated the moderating of the cold in the well water, which was readily done by taking about four quarts of it in a pail and drawing off water from the can to be supplied until the pail was full, when it was emptied into the can. Seven or eight of the eels were found dead in the bottom of the can.

At Rochester met Seth Green at the depot and received profitable suggestions from him with reference to the transfer of young fish.

At Batavia, at 11.35 a. m., the reserve-can was filled from the faucet in the dining-room, the water of the reserve-can being as low as 54° and of the cans 64°. Water moderated before using it.

The water from the reserve-can being again exhausted, at 1 p. m. it was refilled from the penstock, at the east end of the depot, in Buffalo. The temperature of the water was 66°, and the fish-cans 64°. The cans were transferred to the baggage-car of the Lake Shore and Michigan Southern passenger-train.

After leaving Buffalo the fish-cans were again replenished, and at Dunkirk, at 2.10 p. m., nearly two hours after reaching Buffalo, the supply was replenished and a partial change afforded the cans.

At Erie, Pennsylvania, at 4.15 p. m., fresh water was again obtained and furnished the cans; the temperature remaining at 64°.

At Girard, Pa., 4.43 p. m., again filled the reserve-can. The bottoms of the cans were examined for dead shad, and a very few found. Before reaching Cleveland, Ohio, 4.43 p. m., fresh water was supplied, and at Cleveland a can of fresh water brought on board.

The water in the short interval of two hours had become sufficiently exhausted of the respiratory gases to dissatisfy the eels, and, very unfishlike, they were determined to get out of it and find something better. On taking off the cover they were found in large numbers adhering to the neck of the can, entirely above the water, and worming their way up its vertical surface, just as they are frequently seen, while small, at

a dam or waterfall that obstructs their passage up a stream. They persisted in clambering out of the can, and were with the greatest difficulty driven back by repeated washings down with dippersful of water, until it was freshened sufficiently to be agreeable to them, when they settled to the bottom and remained there. A few got out on to the floor of the car, and of course quickly perished. Water was also afforded to the young shad.

At Elyria, at 8.45 p. m., the reserve-can was supplied. The water from the well had a temperature of 54°.

At Sandusky, 10 p. m., changed the water partially, taking only a pailful from the well at the east end of the depot, as the train-men regarded it as poor water.

At Port Clinton, 10.28 p. m., examined fish and found them in lively condition.

At Toledo, at 11.45 p. m., we did not use the water from the artesian well, as it had a strong mineral flavor.

Mr. Mason took charge of fish the latter part of the night, obtaining water at Edgerton, Indiana, 2.04 a. m. He drew the water all away from the eels, finding about one hundred and fifty dead ones. Fresh water was supplied them again. It was evident they required more frequent changes than the shad, or a less number of eels to the quantity of water.

At Laporte, Ind., at 6.05 a. m., the can was refilled for the last time, fresh water having been supplied, about twelve quarts at a time, to each can sixteen times, the eels having had a larger supply at the time of refilling the can.

At 7.30 a. m. of the 15th we reached South Chicago, and Col. James H. Bowen, kindly responding to a telegram from Palmyra, was at the depot with a hand-car, and a boat on the river near by. The shad having been conveyed to this boat were moved up the river for some distance and consigned to the waters in the middle of the river, where no small fish were found to attack them. The young fish were found in vigorous condition, the number of dead ones being very small, and they swam around in the vicinity of the boat very actively and with no appearance of injury from their journey in the cans.

The eels seemed to evince a ludicrous state of elation at their escape from the cans, and showed similar indications of enjoyment of their freedom to what may be seen among a flock of lambs let loose into a pasture from confinement in a pen. They made sudden darts for short distances, and turned right and left, twisting and wriggling until everybody was laughing at their funny antics. A number of them persisted in following the boat as it moved slowly along while we were turning the young shad from the cans into the stream.

At Colonel Bowen's suggestion, one can of shad was retained to be moved up the river some seven miles, in his little steamer, in the afternoon, Mr. Mason remaining to take charge of it and see the fish safely

placed in the water, which was accomplished; Gov. J. L. Beveridge, of Illinois, being the guest of Colonel Bowen at the time, and witnessing the planting. A dozen or more of eels were carried to Chicago for exhibition, and some days later were placed by Dr. Walter L. Haines in one of the ponds at Lincoln Park.

The cans were returned by express to Castleton, and the same afternoon we were on our way back to the hatching-station on the Hudson for a new supply of fish, to be put into the waters of Wisconsin.

12.—SHIPMENT OF SHAD AND EELS TO THE FOX RIVER, WISCONSIN.

We arrived at Castleton on the 17th, and the same evening left again for the Fox River of Wisconsin with about 70,000 shad and 4,000 eels, and we again left by the 9.12 p. m. train.

At Batavia we were delayed a long time by the burning of a baggage-car; and again, on the Lake Shore and Michigan Southern Road, the train was obliged, because of a defective bridge, to take the longer route between Toledo and Chicago via Adrian, so that we reached the latter city one hour too late for the train of the Northwestern Road that should take us to our destination, Appleton, Wis.

The cans were moved to the Northwestern depot, and a convenient supply of excellent water from the hydrant afforded for use, during the day; Mr. Mason, with his usual fidelity, caring for them.

A small can was procured at a tin-shop and about 200 eels put into it to be moved to Big Dead River, at Waukegan, Ill. This task was accomplished by the kindness of Mr. William H. Fay, of that city.

At 9 p. m. of the 19th the fish were again on the way to their destination, and at 10 a. m. of the 20th they were put into the Fox River, Mr. Reid, of the Appleton Post, accompanying us to the point on the river where they were put in. From the long delay there were a larger number found dead in the bottoms of the cans than at the former shipment, though not enough to make any apparent impression in their numbers when looking in at the mouths of the cans. There were probably less than 2,000 dead ones, or a little less than 3 per cent. of the whole number. The fish had been in the cans just sixty-five hours, standing still about eleven hours, and, though the amount of splashing that will benefit larger fish is an injury to shad, still it was made quite evident during our experience that even young shad do better while exposed to the motion of the cars, if managed so that it affect them slightly, than when standing perfectly still. It will be advisable, under similar circumstances, to have them put into a wagon and kept in motion during the delay.

13.—SHIPMENT OF SHAD TO ASHTABULA RIVER, OHIO.

The same evening we again took the return route to Castleton, arriving on the 23d. Your telegram calling me to New York City, Mr. Ma-

son was provided with about 50,000 shad for the Ashtabula River, Ohio, leaving on the same evening, while I took the train in the other direction.

Returning to Camp Green, Mr. Welsher had arrived, and was informed of the purposed shipment to California, which he was to accompany as far as Omaha, Neb.

Mr. Mason returned on the 25th, having put the fish, in good order, into the Ashtabula River on the 24th; Mr. Toombs, express-agent at that point, having afforded him assistance in moving the shad to the river.

In the evening Mr. Livingston Stone, with two assistants, arrived, and also Mr. George H. Jerome, commissioner of fisheries for the State of Michigan, desiring to take back a supply of young shad for his State. Mr. Stone was supplied with cans, tubes, siphons, and pails, and left the same evening for the Sacramento River with 40,000 shad, Mr. Welsher accompanying him as far as Omaha.

The supply of young fish at the hatching-station had begun to fall short, but few shad being taken at the fishery, and indications were numerous that the season was drawing to a close. Our claim for a supply of shad for another shipment was waived in favor of Mr. Jerome, who got away on the 26th with about seventy thousand shad for the waters of Michigan.

14.—SHIPMENT OF SHAD TO THE WABASH RIVER, INDIANA.

On the evening of the 28th Mr. Mason and I started for Logansport, Ind., with four cans of shad, about forty thousand. The weather was very warm, and we made use of a small quantity of ice in our reserve-cans whenever the temperature of the water was above 67°.

We arrived at Logansport at 8.50 a. m. of the 30th. Messrs. Bryer and Hunt of the Logansport Journal generously interested themselves in the work of moving the fish to the river, and Colonel Bringhurst, with a knowledge of the character of the waters in the vicinity, selected a locality in Eel River, a large tributary of the Wabash, into which the young shad were put, in fine condition, and with scarcely any dead ones.

We started for Castleton early in the evening, and arrived on July 2 to find the station abandoned and the boxes and apparatus stored away until another year. The season, as anticipated, had closed.

Arranging unsettled matters, and providing for the storage of some surplus apparatus, we left the same evening for South Hadley Falls, Mass., Mr. Mason and Mr. Welsher joining me in Albany.

At South Hadley Falls found Mr. C. C. Smith superintending the hatching-station for the Connecticut fish-commission. He had some seventy boxes in operation, with eggs and shad in various stages of development, and was taking from twenty to ninety spawners nightly, affording large quantities of ova.

Mr. Welsher had been sick during the trip, and, feeling worse, returned home to Rochester, N. Y.

15.—SHIPMENT OF SHAD TO THE WATERS OF LAKE CHAMPLAIN, VERMONT.

On the evening of the 4th, with six cans, containing a much larger number of fish than in previous shipments, about one hundred thousand, we started for Burlington, Vt., intending to place the fish in the Winooski River. The weather being very warm we made free use of ice. We arrived in Burlington at 7 p. m. of the 5th, and, accompanied by Mr. H. S. White and a gentleman connected with the Burlington Free Press and Times, we drove to the river and put in the shad, in very fine condition, the loss being hardly apparent.

During 1872 a quantity of shad were planted at Whitehall, N. Y., the head of Lake Champlain, under the direction of Seth Green, and a quantity put in at the dock by Dr. M. C. Edmonds, commissioner for the State of Vermont. This season at the mouth of the Winooski, and at the shore of the lake at Burlington, a number of unmistakable shad five or six inches in length, had been taken; a son of Mr. H. S. White, in one instance, compelling their return to the waters.

We returned to South Hadley Falls, arriving on the 6th, (Sunday,) and remained at Holyoke, Mass., until the next day.

16.—SHIPMENT OF SHAD TO THE HOUSATONIC RIVER, CONNECTICUT.

In response to a telegram to Dr. W. M. Hudson, commissioner for the State of Connecticut, proposing to move fish to the waters of the State, the reply was received: "Take as many as convenient to New Milford, on the Housatonic."

On the 8th we started with 90,000 shad and arrived at New Milford in the afternoon, putting the fish in the Housatonic River with scarcely any loss. Although the people of the vicinity were wide awake to the fishing interests, and appreciated perfectly the value of stocking the waters with valuable fishes, their enthusiasm was very much checked by the condition of a fish-way in the dam at Birmingham, lower down the river, which was represented as in no particular constructed according to the models in use for this purpose, and was of no value whatever for the passage of fish.

We started back the same afternoon, arriving at the hatching-station the morning of the 9th. In the afternoon we witnessed the sport of taking shad with a fly-hook*. A citizen of Holyoke, Mr. Thomas Chalmers, has made this line of hook-fishing quite popular on the Connecticut by his successes; on this evening we saw him take eleven full-grown shad. The tackle used is a trout or salmon rod, with a reel containing one hundred or more feet of line, and a small hook (about No. 6) with a brown fly. A peacock body, long, turkey-feather wings, and light-brown hackel is the fly in common use. Two persons in a boat select a spot where the current is quite rapid, and anchor the boat and let their

* A prevalent impression that this is a new sport will be corrected by referring to page 181 of Frank Forrester's Fish and Fishing, &c., by Wm. Henry Herbert, 1850.

flies trail down stream, with about 60 feet of line out, the whirl of the current keeping the fly in play at the surface. The first pull of the shad will bend the pole into a circle, and its weak mouth necessitates the most skillful play and management to get it near the boat, where it is usually taken in with a dip-net.

A singular point to fish from was the high bridge, some 40 fe t above the water. A number of men and boys were always to be found in the evening with long hand-lines trailing down stream over the bridge-railing. When a shad took the hook he was carefully drawn in until he was landed on one of the small islands beneath the bridge, and allowed to remain there until life was nearly extinct, when he was drawn up on the bridge. Of course many more were lost this way than when fishing from the boat.

17.—SHIPMENT OF SHAD TO THE PENOBSCOT RIVER, MAINE.

On the 10th we started for the Penobscot River, Maine, with 100,000 young shad. While waiting at Portland some four hours between trains, Mr. Mason went over to the bay and brought a pail of sea-water. About two dozen of the shad were taken from a can and put directly into the salt-water and were allowed to remain in it over two hours, at the end of that time they were all apparently in as healthy and lively condition as when taken from the fresh water, neither the salt nor the difference in specific gravity affecting them in the least. If this experiment should prove successful for a longer period of time, it would make the transportation of shad across the ocean a comparatively easy task. And it would be well worth while for some fish-culturist situated conveniently to the sea-coast to experiment on other species of young fishes, as, if successful, it would simplify the carriage of fish on long voyages very much.

From Bangor, Mr. E. M. Stilwell, commissioner for the State of Maine, accompanied us to Mattawamkeag, fifty-eight miles above Bangor, on the Penobscot River, at the junction of the Mattawamkeag River, where the young fish were consigned to the waters, in good condition, at 1 a. m. of the 11th.

18.—ESTABLISHMENT OF STATION ON THE ANDROSCOGGIN RIVER, MAINE.

On the 14th we arrived in Topsham, Me., with the purpose in view of establishing a hatching-station on the Androscoggin River, and the same evening employed a party of men to haul the seine about two miles below the dam.

A hatching-box was hurriedly made up from a soap-box and a piece of millinet, but the result of the fishing disappointed us, as only eight spent shad were obtained, all of them with the abdomen shrunken and slender, indicating that the spawning season was over with them.

The next night, the 15th, four hauls were made, resulting in eight

spent shad, males and females, and it was decided to abandon the attempt for the season.

19.—SECOND SHIPMENT OF SHAD TO THE WATERS OF LAKE CHAMPLAIN, VERMONT.

On the 18th, receiving a favorable answer from South Hadley Falls in reply to the inquiry whether young shad were still to be had, we returned to that point on the 19th, and the same evening started for Vergennes, Vt., with 100,000 shad, to be put into Otter Creek, a river emptying into Lake Champlain, seven miles below the town. Dr. Hopkins, a resident, afforded us assistance in conveying the cans to the river and in finding a proper place for turning them free in the waters, which was done early on the morning of the 20th, there being scarcely any loss in the cans.

Remaining in Vergennes during Sunday, we returned to the hatching-station on the 21st, and found that we should have to wait until the next evening to obtain a supply of fish, which we intended to take through to Michigan.

20.—SHIPMENT OF SHAD TO THE DETROIT AND GRAND RIVERS, MICHIGAN.

On the afternoon of the 22d, with 100,000 shad in the cans, we started for Detroit. At Toledo, Ohio, we were obliged to wait over about nine hours, and arrived in Detroit on the 24th. Mr. George Clark, of Ecorse, one of the State fish-commissioners, joined us before reaching Detroit, and with his advice about 20,000 shad were put into the Detroit River, near the Detroit and Milwaukee Railway depot, and the remaining 80,000 carried to Ionia, Mich., where they were put into the Grand River about midnight of the 24th, being in vigorous condition, and with but a small percentage of loss.

Mr. J. Mason returned home from Detroit, as this was the last shipment of shad for the season. I desire to refer to him as a man of marked fidelity and conscientious faithfulness to the work allotted him. To his continued attention and skillful judgment in the care of the young fish is due the success of the transfers just recorded, and though the lack of the least failure in the different shipments referred to might lead the inexperienced to think it an easy task, there are many who have attempted the work this season who would acknowledge that it was anxious, toilsome, wearying work, resulting in failure and loss after every effort possible was made to prevent it.

Table of distribution of shad and eels.

Shad-hatching stations.	Rivers planted.	Eels.	Shad.
UNITED STATES COMMISSION.			
Potomac River, Washington, D. C.	Greenbrier River, Ronceverte, W. Va.	....	50, 000
	New River, Central Station, Va	....	40, 000
Delaware River, Lambertsville, N. J.	Monongahela River, Greensburgh, Pa	....	15, 000
NEW YORK STATE COMMISSION.			
Hudson River, Coeymans, N. Y.	Calumet River, South Chicago, Ill	4, 000	70, 000
	Fox River, Appleton, Wis	3, 800	70, 000
	Big Dead River, Waukegan, Ill	200	....
	Ashtabula River, Ashtabula, Ohio	....	50, 000
	Wabash River, Logansport, Ind	....	40, 000
	Jordan River, Jordan, Utah Ter	....	5, 000
	Sacramento River, Tehama, Cal	....	35, 000
CONNECTICUT STATE COMMISSION.			
Connecticut River, South Hadley Falls, Mass.	Winooski River, Burlington, Vt	....	100, 000
	Housatonic River, New Milford, Conn	....	90, 000
	Penobscot River, Mattawamkeag, Me	....	100, 000
	Otter Creek, Vergennes, Vt	....	100, 000
	Detroit River, Detroit, Mich	....	20, 000
	Grand River, Ionia, Mich	....	80, 000
	Total	8, 000	865, 000

21.—MODE OF ESTIMATING NUMBERS OF EGGS AND FISH.

The estimation of the numbers of shad-eggs and of the young fry is a rather difficult matter to accomplish satisfactorily or with even approximate definiteness. The standard made use of on the Connecticut River is, without doubt, very much too high. Mr. C. C. Smith, who is a most faithful and successful breeder, has adopted the exaggerated estimates of his predecessors, and in the earlier years of his work, when the restoration of the shad by artificial propagation was an experiment, the contraction of the round numbers that had appeared in the reports of previous years might have discouraged the people and the legislators, and the support that was so necessary to this initiation of the work might have been withdrawn. But now that the experiment has proven itself so thoroughly and evidently a success, and the river is again teeming with shad, it makes very little difference to the citizens of the State whether it has been accomplished by placing 10,000,000 or 90,000,000 of young shad in the waters, and a system of measurements and counts should be carried out so that some more definite knowledge of the number of eggs handled may be attained. One of the commissioners of the State, in 1870, feeling dissatisfied with the estimates afforded, attempted to induce more careful modes of numbering the eggs and fish, and in the following year succeeded in having them modified to a certain extent. The numbers of fish we carried in the six cans were, by these standards, millions, while the most careful means of numbering we could employ did not place them over from twelve to twenty thousand to the can.

In estimating the numbers of fish in the cans, we had, as our sole reliance for accuracy, only their apparent thickness in the water, which, after considerable experience, afforded an approximate estimate within a margin of a few thousands of the real number.

Seth Green's instructions to his men were, to fall within the whole number of fish rather than to exaggerate the quantities. The numbers they were in the habit of estimating in the cans, taken from the boxes, would not account for the number of eggs impregnated and placed in the boxes, and for which much more accurate means of numbering were available than for the young fishes.

It was determined, while at the hatching-establishment on the Connecticut River, to attempt to obtain a more definite knowledge of the numbers of fish we were planting in different rivers.

To do this, dippers full of fish were taken, having the shad about as thick in the water as we had been accustomed to carry them in the cans. These were carefully counted, and, knowing the number of dippers full that were put into a can, we found we had been calculating about 35 per cent. (probably rather more than this) short of the actual number carried.

As it is scarcely practicable to ladle out the shad-eggs into the hatching-boxes, a very good mode would be to have lines either graved or painted around the insides of the impregnating pans, and their distance from the bottom would show approximately the number of eggs, if this should be determined in the first place by weighing the quantities that would fill the pan to the lines, and counting a definite fraction of the weight.

An overestimate in any locality, of course, places more accurate estimates in other regions in unfair comparison, and, too, the more exactly and correctly we understand the extent of the means necessary to produce the results required, the more definite our knowledge and the greater precision in the direction of the efforts to be used.

Judging from the reports of State commissioners and the general literature of pisciculture, there is a well-understood need for some definiteness and uniformity of standard in estimating eggs and young fishes among practical workers; and it would employ the time of some one interested to good advantage if he would devise methods for this purpose sufficiently practicable to receive the approval of others of the profession. The occasional discrepancies that are discovered in published statements, between the sums of the number of eggs received and the number of young fishes produced from them, indicates the great need there is in this direction.

22.—THE CARE OF YOUNG SHAD DURING TRANSPORTATION.

(22*a*.) *The apparatus.*—The apparatus used in the transfer of the fish we had obtained in Washington, modeled after that seen in Seth Green's establishment near Rochester, N. Y. It consisted of the articles described as follows:

The cans were large fifty-quart milk-cans, made in the best manner, from the strongest material used by the manufacturers; the principal

necessity in their model is the shoulder arched in toward the neck of the can; this, when the water fills the can quite up to the neck, has the tendency to confine, or, as I have heard it termed, "to bind" the water and prevent the violent splashing that a large area of surface would be subject to, and that would be of great injury to the delicate young fish.

A piece of rubber-hose about twice the length of the can to be used as a siphon when drawing down the water in the cans of fish preparatory to replenishing them with fresh water.

A tin tube the length of a can and about two inches in diameter, one foot of the lower portion being made of perforated tin, is to be used with the siphon, the tube hanging from a hook, soldered to its upper end, to the mouth of the can and the rubber-siphon being put down inside of the tube draws the water from within it, the perforated tin preventing the young shad from being drawn through, though the water has easy access.

The rubber-tube should not be more than three-fourths of an inch in diameter, as a larger siphon would create too strong a current through the perforations, and lodge and injure the young fish against the sides of the tube. For the same reason it will be seen that an attachment of perforated tin tube to the bottom of the rubber-pipe, though a simpler instrument for the purpose would be injurious, as a much less current is created through the orifices in the large area of a tube of wide diameter than one having a small one.

A couple of tin pails for carrying away the stale water and obtaining fresh water from pumps and hydrants, a thermometer to observe temperatures of the water on the fish, and a tin dipper, completes the simple apparatus required for the successful transfer of young shad.

(22*b*.) *The care of the fish.*—The care of fish while transporting them is an essential part of the art of fish-culture, and often requires more skill and judgment than the propagation of young fish.

The shad are perhaps the most delicate and most liable to loss of any fish handled in this country. Many who have been successful with salmon and trout have failed entirely when attempting to transfer shad even for short distances. Still, their proper care and treatment is a very simple matter. The first essential is continual attention. For any long distance there should be two persons in attendance, relieving each other at intervals of several hours; and on no account, no matter how flattering the conditions of the young fish may be, should they both lie down to sleep at the same time.

From 12,000 to 24,000 are safe numbers for a fifty-quart can when carried from ten hours to three days, if good water can be afforded as often as once in two hours. For a trip to California, occupying from six to eight days and with several days without a supply of fresh water, 5,000 to the can would probably be as many as it would be advisable to carry.

Experience only will enable one to judge from their appearance in the water as to the numbers that have been put into a can.

The principal means for sustaining life and vigor in the fish is affording them supplies of fresh water. Minute as they are their gills are developed and their breathing exhausts the respiratory gases from the water more or less rapidly according to the numbers in the can. Even the ova, it has been proven by experiment, utilizes a small portion of oxygen from the air.

A reserve-can is required for every five or six cans of fish, which should be filled with water at the stations, generally where the locomotive takes wood or water or where meals are afforded, the attendants remembering to fill the can first and eat the meal afterward. A pailful or two may often be obtained at minor stations.

The tube is put into the can, hanging by the hook from the top so as not to roll about and bruise the young fishes, and one end of the rubber-pipe inserted in the tube. Apply the mouth to the other end of the hose and suck until it has filled with water; the end is to be at once lowered into a pail, when the water will run freely until the pail is full. This water is to be thrown out at the door of the car and the same quantity of fresh water replaced from the reserve-can, filling a dipper and lowering it to the surface of the water in the fish-can before it is emptied, until sufficient has been afforded.

An examination of the bottom of the cans for dead fish can be made by tying the rubber-hose to the end of a piece of lath, and then, while guiding the end of the hose by means of the lath around the bottom of the can, start the water running, and dead fish and settlings at the bottom of the can can be drawn off into a pail. On a long journey, of five days or more, the shad may be transferred from one of the fish-cans by means of the siphon to the extra one, and the can be scoured clean from slime and sediment, and the fish from another can being emptied into it by the same means this can in turn be cleansed, and so on throughout them all.

In moving the cans from car to car or into a wagon, care must be taken that they are carried upright, as the least spilling of the water through the crevice around the cover, if examined, will be found to contain young shad. A spring-wagon should be used, if possible, in moving them by this kind of conveyance, as the jolting of a common wagon will be found to splash the water much more than a railroad-car, unless driven very slowly.

(22c.) *Water adapted to young fish.*—Tests made in keeping young fish in different waters prove that but little danger is incurred in using it from any source where it is clean, of not too high or low a temperature, and free from decayed matter. The clear water from springs and wells, though nearly destitute of living forms, answers the very best purpose in carrying shad. Clear river-water full of minute forms of life is perhaps preferable for fish after the yolk-sacks disappear. Seth Green,

when carrying through the first shipment of shad to California, found them on the sixth and seventh days out looking for food, and felt satisfied from their actions that they found it in the water supplied them from the rivers after passing the region of impure waters.

Mineral waters may inspire fear, and it is perhaps premature to advise their use, but that they are not all injurious has been proven by several tests made this season. While at Toledo, Ohio, the water of the artesian well at the depot, clear and cold, but having a strong mineral flavor, thought to be sulphur, was avoided for use in the cans, but a couple of quarts were put into a vessel and about two dozen shad put into it about midnight, and remained in most perfect condition up to 8 o'clock in the morning, when they were put into the Maumee River.

At Castalia, Ohio, at the paper-mill of Mr. John Hoyt, speckled trout are hatched and raised successfully in water from a spring so heavily charged with calcareous matter that the tufa incrusts everything falling into its waters. Prof. J. Lang Cassels, of Cleveland, found that out of ninety-two grains of solid matter to the gallon there was of carbonate of lime 58.86 grains, and of carbonate of magnesia 10.632 grains.

Seth Green, in his trip with shad in 1871, found water from Omaha westward for four hundred miles unfavorable to the shad, and in some of it the young fish died within five minutes from the time they were put into the vessel containing it.

All mineral-waters should be used cautiously and tests made with small quantities of water before they are used on the fish in the cans.

While at Portland, Me., this season, two dozen shad were removed directly from fresh water and were kept in a few quarts of sea-water for two hours without the least apparent injury from the salt or the greater specific gravity.

There are some who assert that roily water has no objections for use with young shad. If there were no other objection the anxiety as to the condition of the fish, which it is almost impossible to ascertain in muddy water, is a sufficient one. Besides, the silt or sand is liable to trouble the movement of the gills, and the attrition upon the delicate membranes of the embryo fish, while the water is agitated in the railroad-car, must do some injury to them. And the experience of this season's work has been that the large percentages of losses in the cans have been when roily water had been used at some locality while *en route*, and of course indicating that a longer use of it would have resulted disastrously. When it is necessary to use muddy water, as soon afterward as clear water can be procured, the largest change practicable had better be afforded the cans.

The water from railroad-tanks, though avoided during this season's shipments, was, perhaps, rejected through a somewhat unfounded prejudice. Where few locomotives are supplied, the water may become warm, stagnant, and tainted from decaying wood, but when the tank is frequently replenished with fresh water no such objection can arise,

and the water is, without doubt, nearly as good as if taken directly from its source.

On the few occasions when we have been obliged to obtain the water from the tank in the tender, it was found clear and pure, and with no indications of oil or grease, and it is probable it would always be found so.

(22*d.*) *Temperature of the water in the cans.*—The temperature of the water which the fish are in is also an essential point in their welfare.

A too low temperature produces lethargy and torpidity in the young shad, which, if suffered too long, occasions death.

The young shad suffer in low temperatures in which the *Salmonidæ* thrive well. By experiment it has been proven that between 65° and 72° the shad are found to be in the best condition. The springs of the lake region have from 46° to 50° of temperature, the deeper wells from 54° to 60°, and the streams from near the freezing-point, in winter, to 85°, perhaps more, in hot summer-weather.

Where there is six or more degrees difference in the water of the reserve-can and of that on the fishes, the temperature of the fresh water should be moderated before using it. This is readily done by preserving a portion of the stale water drawn from the fish, which can be aerated by repeated pouring from the dipper, the pail is then filled up from the fresh water, and according to the proportions used the temperature can be raised before supplying the can containing fish.

A temperature higher than 80° is dangerous, as the fish become weak, the supply of respiratory gases in the water is much less, and the fish very soon die. In hot weather the use of ice is necessary where water from wells or springs cannot be obtained. The ice should be applied in the reserve-can, and not in the cans with the fishes, as in knocking about on the surface it kills many of them, and if in the splashings of the water any are lodged on top of the ice they soon die. Caution must be taken in using ice in the fresh water, not to put in sufficient to reduce the temperature below the proper standard.

(22*e.*) *Transferring the shad from the cans to the river.*—On arriving at the river the first necessity is to determine that the temperatures of the cans and the stream are so nearly equal as not to endanger the fish when consigned to their new home. If there is five or more degrees difference, it can be readily equalized by drawing a quantity of water from the cans and filling them up again with the river-water.

The locality for planting should be chosen so that the fish will not be too soon carried into the whirl of a rapid current, but may recruit for a time from their fatigue, and, possibly, their hunger, before being obliged to struggle with swift running water.

Another very important matter is to avoid schools of minnows or other small fishes, who will congregate at the spot in large numbers and devour a large proportion of the fish that have cost a large amount

of pains and labor to be conveyed to the spot. The middle portion of the stream or inlet is generally the freest from the smaller fry.

When the locality is selected, the temperature equalized, and a boat provided, there is nothing more to do than to lift a can over the side of the boat, dropping it upon its side into the water, and while the boat is leisurely pulled up stream the young fish are allowed to slowly escape from the can. Scattering them along a considerable distance is thought to be the best for them, as they make less attraction for predatory fishes when widely distributed than when concentrated in a large school, and, as they are probably not gregarious while so young, they are not likely to collect together immediately.

(22*f*.) *Facilities required from the railroads.*—The necessities and conveniences required in the transporting of young shad are peculiar, and different from all other freightage. Fish-eggs, when properly packed, are shipped with safety without an attendant, requiring only that the express-messenger follow the few instructions lettered on the outside of the can or box. Young trout and salmon are occasionally shipped short distances in the same way, the water having been reduced to a low temperature, so that the respiratory action is lessened and frequent changes of water are not required.

The shad are found to withstand confinement in a small quantity of water with much less endurance than other species that have been experimented with. There is very little tenacity of life in the mature fish when removed from the water, and attempts to preserve male fishes for "milters" from one seine-haul to another, have been failures, even where they were confined in an inclosure through which the water of the river circulated. A temperature sufficiently low to retard respiration does not work to advantage with the shad, and experimenting with reference to favorable temperatures has proven that a range between about 62° and 78° is the only one suited to their welfare, while 65° and 72° are better limits. Frequent changes of water are required, necessitating hurried visits to pumps and hydrants when the train stops, and it is sometimes necessary to procure and use ice; so that it will be seen that experienced attention is required and too much time occupied in the care of the fish to permit the work to be given into the hands of messengers usually having sufficient to occupy their time in their regular duties.

The amount of room afforded, the facility for getting out and in, and the less rigid enforcement of regulations as to access to the car, to say nothing of the liberality frequently extended in passing the freight without charge, makes the baggage-car the only suitable place for the transportation of shad, or for any species of fishes for long distances.

The inconvenience of carrying large cans of water in the car because of the slopping, will probably suggest itself to some, but experience has proven that with a little care there is no necessity whatever of wetting the bottom of the car, even around the spot where the cans are placed.

The necessities in the work depending on the accommodations afforded from the railroads, are access to the baggage-car and opportunities to obtain water from wells, hydrants, tanks, and the tender. In all these particulars the most generous spirit has been manifested by both managers and employés.

23.—POSSIBILITY OF STOCKING THE GREAT LAKES WITH SHAD.

The stocking of fresh waters with fish from the sea, or of those who spend a portion of their lives in the sea, will perhaps be questioned by many as an uncertain experiment and likely to end in failure.

The conditions found in their natural homes of which the shad may avail themselves may be enumerated as follows: Streams of the right volume of fresh water and the right temperature, to ascend in the spring season to deposit their spawn, and in which the young shad will find a favorable home until they are the proper age to descend to the sea; a great body of water of unlimited volume on the bottom of which the small forms of *Crustacea*, the *Gammaridæ*, and *Mysidæ*, small shrimp-like animals, are found abundantly, affording an ample supply of food during the greater part of the year, as but very little is ever found in their stomachs when they are up the streams in the spawning season. Another condition of this great body of water is that it is salt.

In all these particulars but the latter the lakes answer every demand. There are streams suitable for spawning localities; there is an unlimited range of clear, cool waters; the dredgings on the bottom at all depths have proven these same crustaceans of the *Gammaridæ* and *Mysidæ* to be abundant, and except in the one particular of the saltness of the sea every requisite condition of their natural home is afforded them. The only point to be tested in the experiment is whether this is an essential requirement in their existence.

Several species of white-fish found in the Arctic Seas live indifferently in salt and fresh waters, and the *Coregonus omul*, as related by Pallas, sends off large detachments from its schools in the spawning season from the sea up the long series of streams and lakes that find their head in the great Lake Baikal, where the schools find a permanent home, never returning to the sea.

The eel, brook-trout, striped-bass, and several other species on the eastern coasts, live indifferently in the sea and fresh waters.*

It is not probable that all fishes which spend their entire lives in the sea could become accustomed or acclimated to fresh waters. Still, among these it would not be unlikely to find a few having strong tenacity of

*Günther says, in referring to *Gobiidæ*, that "This family offers numerous instances of the fact that a part of the individuals of one and the same species are entirely confined to fresh waters, whilst others live in the sea."—*Cat. Acanth. Fishes, &c., vol. 3, p. 1, by Dr. Albert Günther.*

life that would endure the change of condition without detriment to their health and vigor, provided their proper food was supplied them.

But it is the habit of those most desirable to transfer, to spend a portion of each year in fresh water, and it is difficult to find the reason why if the salt-water is not essential to them part of the year it should be during the remainder. The absence of their proper food in the streams they ascend would seem to be the principal necessity for their return to the sea.

Experiments in planting salt-water fishes in fresh waters have been made heretofore with success. The striped-bass of the Atlantic waters has been kept for a number of years in inland ponds. Rudolf Hessel, a fish-culturist of Europe, informed me that he had put a number of flounders in Lake Constance, of Switzerland, several years ago, and that fishermen occasionally found them in their nets at the present day.

The transfer of shad to the lakes was not, however, an entirely new experiment. Seth Green, when moving shad to the Pacific coast in 1871, made small plants at Cleveland, Toledo, and Chicago, and the same year put 5,000 shad into the Genesee River, of New York State.

At Toledo, Ohio, last fall, the firms of Bowes & Howell and Davis, Brother & Beatty reported having had unmistakable shad in their ware houses during the season. These were undoubtedly from Mr. Green's planting. At the Genesee River many shad were taken in the nets of the fishermen developed from the young of the planting of 1871. In the latter case they might possibly descend to the brackish waters of the Saint Lawrence, but in the former they must necessarily have spent the whole of the intervening year and a half in fresh water.

The finding of the yearling shad in Lake Champlain has been referred to on another page. Two plantings were made in 1872 at Salamanca, N. Y., in the Alleghany River, and one at Indianapolis, Ind., in the White River. At Terre Haute, Ind., this season, young shad were taken from the Wabash River that had strayed thus far from the place where they had been consigned to the waters of the Ohio Valley.

All these facts afforded sufficient hope of success to warrant a large planting of shad as an experiment in the lakes.

24.—POPULARITY OF THE WORK OF THE COMMISSION.

In continual conversation with those I have met a uniform approbation and satisfaction has been expressed that an effort was being made to restore the stock of food-fishes in the waters of the country, and from citizens of those States we have not been able to benefit this season, the desire was expressed that their claims should be regarded as early in the future as possible. The general awakening all over the country to the interest of food-fisheries is indicated by the numerous bills passed in the legislatures in late years.

Of the States bordering on the lakes, Vermont, New York, Penn-

sylvania, Ohio, Michigan, Wisconsin, and Minnesota have appointed commissioners and made appropriations for propagation, while Indiana and Illinois have passed protective laws as to the obstruction of the passage of fish in the rivers.

The State of Michigan has erected a large hatching-house, and will propagate the white-fish of the lakes on a large scale. The judicious management of the New York State commissioners has made their work very efficient, and people from all quarters of the State have visited the hatching-house and carried back thousands of young fish, without charge, to stock the waters in the vicinity of their homes, some half-dozen species of food-fishes being afforded in quantities to all who applied.

A very general and strong interest was exhibited on the southern rivers at the attempt to hatch shad, which made very little success, because of the great reduction of numbers in these waters and the consequent lack of spawners. The promises to endeavor to supply their rivers with a new seed-stock from more northern rivers was met with earnest interest and satisfaction.

XX.—NOTES ON THE NATURAL HISTORY OF THE SHAD AND ALEWIFE.

A—NOTES ON THE SHAD AS OBSERVED AT BEAUFORT HARBOR, NORTH CAROLINA, AND VICINITY.

By H. C. Yarrow, M. D.

Beaufort Harbor is situated on the coast of North Carolina, about fifteen miles southwest from Cape Lookout. It communicates with Pamlico Sound to the northward through Cove Sound, and with the Atlantic Ocean by Beaufort Inlet, Onslow Bay, and a number of small inlets from Onslow Sound. The accompanying map will, perhaps, show its position better than a mere description. From its peculiar position and surroundings, having a great number of outlets, we might suppose it a favorite resort for fish of all kinds, which is indeed the case, as the locality is a noted one.

Among the fish visiting the shallow waters of this bay not the least in importance is the shad, (*Alosa præstabilis*, De Kay,) so well known as an important item of food both South and North. From the fact that the only fresh-water river leading from this body of water is small and short, we should not expect to find the shad as numerous as in more favorable localities. Indeed, the general impression among fishermen seems to be that as the schools of fish gradually work their way North early in the spring, searching for their favorite breeding-grounds, stragglers become separated from the main bodies, and are from this circumstance taken near Beaufort. However well grounded this belief may be, recent careful observation will hardly bear it out, as it is now thought by observers who have given much attention to the subject, that the fish, after leaving their breeding-grounds simply swim into deep water, not a very great distance from the mouths of their respective rivers, remaining there until the sexual instinct again impels them to re-enter. Of course, those shad hatched in the Newport River, the one mentioned, would also return. From the limited yield of the shad-fisheries at this place, I can hardly consider it at present a favorable breeding-ground, although it is stated that in former years the catch was much greater. If the fishermen's theory above named is correct in regard to stragglers, it may be possible that the few shad who enter, finding circumstances unfavorable for breeding, remain but a short time, going out to sea again soon after entering. I may here mention that the facts given below in regard to this fish are compiled from my notes taken while on duty at this point, and from the experience of a large number of fishermen with whom I have conversed.

The first shad taken near Beaufort appear about the 25th of December, and from this time until the latter part of May they are taken in more or less numbers, increasing generally toward the latter part of the season, although for some years past the largest catches have been in March.

As already stated, the number of fish captured is not very great, being about one-fiftieth, as compared to the so-called herring, (*Pomolobus pseudoharengus;*) but in making this comparison it must be remembered that this is not a good ground for the fish mentioned, nor is fishing for the herring systematically carried on to anything like the same degree it is in the waters of the Neuse River, not many miles distant. According to many observers, shad formerly were very numerous in this region, and have probably decreased 30 or 40 per cent., the reason for this diminution being, in the opinion of the fishermen, the filling up of Beaufort Inlet. In view of the fact that there still remains 14 or 15 feet of water in the channel, which is apparently sufficient to admit large schools of fish, I hardly think much credit can attach to the statement, unless some other causes operate to prevent the entrance of the fish. It may be as the channel has changed, forming shoals in some instances at right angles with the shore, the fish either coming up from the south or from the ocean, striking the shoals, are deflected off toward deep water, and thus pass the inlet. As the cause mentioned has greatly interfered with the mullet-fishing at this point, it may also have done the same with regard to other fish.

Shad taken near Beaufort, though generally small, frequently reach a length of 18 inches, such a fish weighing from 4 to 6 pounds, but the average length of those taken will not exceed 15 inches, the average weight from 3 to 4 pounds. It is supposed that about three years are required for a shad to attain its full growth, but in the absence of reliable and positive data this statement is given for what it is worth. With regard to difference of shape and rate of growth between the male and female, the latter is supposed to grow rather faster and is always the largest, having a broader back and more protuberant belly.

The different modes of entrance of these fish are through the different inlets into the sounds of this part of the coast, and their movements in entering and leaving are entirely similar to those of the so-called herring or alewife. It is a mooted question as to the winter-residence of the shad, some inclining to the belief that they remain in the warm waters of the Gulf of Mexico, while others believe that they run out to the deeper waters of the ocean. The latter theory will probably prove the correct one. The first appearance of shad at Beaufort Harbor, as has already been mentioned, occurs about Christmas, and from this time they are only scattering, until March, when the larger runs take place, but as

the runs become larger there is no increase in the size of the fish except the female; from this time the runs decrease, the fish leaving gradually, the same as they entered. So far as known the shad invariably appear each succeeding year, but there is a very marked irregularity of number and size, the last arrivals being nearly always the largest. On entering the inlets both sexes appear to be about equal in numbers, the ovaries of the females being about 3 inches long. Upon the entrance of these fish their presence is indicated by their swimming near the surface of the water, producing a ripple, the gathering near of birds, and lastly, their capture in the herring-nets. In common with very many other fish, they invariably run in with the tide, going out with its ebb, and these movements I believe to be invariable. As the female shad is not far advanced toward spawning on entering the sounds, it is but seldom the spawn is seen running from them when captured in nets, more especially as few are captured when the eggs are near maturity. It is believed this fish is strictly anadromous, that is, it regularly returns from the sea to the fresh-water rivers for spawning, and from its first appearance off the coast about December 1, it would seem that the sexual instinct, which impels it to visit fresh water, is strongest a short period anterior to this time, providing that the theory be true of their wintering in the deep waters of the ocean. At this time their rate of progression is estimated at about eight miles per hour. In regard to their stay in fresh water, it is probably not later than the last of May, as after this time but few are seen. At the locality under discussion, though quite a common notion, not at all likely to prove true, it is said no spent shad have ever been taken, and that but few ever live to get back to the sea, not so much on account of their feebleness after spawning, but on account of their being nearly all captured. As to the habits at this time, no difference has been observed in the sexes. In coming in the breeding-grounds, all aged fish are probably seen together, although many persons state that yearlings do not herd with older fish, and in fact remain in rivers for over a year after hatching, although as yet it has been deemed almost impossible to determine accurately their ages. The most favored localities by these fish are in deep water, with a fair running current, although for spawning they prefer shallow, sandy ground, where the water is warm, not over 16 to 20 feet deep. After spawning shad no longer keep together in schools, but scatter and make their way from the breeding-grounds singly or a few together. This statement, though not positively proven, is believed to be correct.

With regard to friends and enemies among other fish, they appear to possess few of either, though herring and rock-fish are frequently found in their company. They neither prey upon or suffer from the attacks of other fish, their principal food appearing to be sought in small pebbles and gravel, and is probably small crustacea, and perhaps

algæ, as I have noticed a greenish substance in their stomachs; the amount is doubtless small, as the stomachs are nearly always found empty. The only interference in spawning is caused by traps and nets and unusual floods of water which wash gravel over the spawn, thereby destroying it.

It is stated, and generally believed by fishermen and others, that shad begin to breed when one year old, and are able to breed for one year only; this statement cannot, I believe, be considered as reliable, as Mr. Milner has found in the ovaries of spent shad the undeveloped eggs of succeeding seasons. During the spawning-season no well-marked change of appearance has been noticed, except the larger belly of the female, and a greater brilliancy of general coloration. The act of spawning seriously affects the shad in different ways; it produces emaciation and weakness not only in the female, but male fish, and deteriorates their flesh, rendering it flabby and tasteless; these results are due not only to the propagation act, but to the amount of physical energy necessarily expended in reaching the head-waters of rivers, their favorite spawning-grounds. In the act of spawning the males and females appear to run indiscriminately together, although Mr. Lyman, of Massachusetts, has seen them at this time paired, and it is but seldom the water is seen colored with the milt of the male. The most favorable temperature for hatching is warm, the eggs being laid near the surface of the water. The size of the individual egg is larger than that of the pseudo herring, and from 100,000 to 150,000 is the number estimated for each female. The eggs when spawned sink to the bottom, and are not attached to stems or gravel floating freely in the currents; no nest of any kind being built by either male or female, nor do they watch the eggs until hatched, which event takes place late in the season, probably June or July. The time required for hatching depends mainly on the temperature of the water, from seventy hours to six days being required. Of the total number of eggs laid, it is estimated by fishermen that probably one-tenth are hatched; this I believe to be a large estimate, and of the young reaching maturity, not more than one-fifth survive. From evidence received, it is believed a much smaller number are hatched, but a larger portion reach maturity.

The rate of growth is said to be about 4 or 5 inches per annum; but this statement has not been confirmed by personal observation. After hatching, the young fish receive no care from either parent, and suffer greatly from the attacks of other fish. In fact, there appears to be no parental instinct whatever, as shad are known to have devoured their own eggs. It is but seldom the young fish are seen after hatching, or if seen, are not recognized in the waters near Beaufort, although observed in other streams. They appear to live on similar food to their parents.

No steps, thus far, have been taken by the authorities of North Carolina to increase the abundance of this fish by artificial breeding, although a few public-spirited gentlemen of New Berne, N. C., are trying to influence local legislation with a view to this laudable object.* Legislation upon the subject of preserving the fish-supply has received its full share of attention in the southern seaboard States, but the law is practically a dead letter.

No disease has ever been noticed prevailing as an epidemic, nor do parasites as a rule infest shad; although occasionally sea-lice are found hanging near the gills.

The only two methods of capturing shad in this locality are with draw and gill-nets; the former being from 150 to 500 yards long, 8 to 16 feet deep, with a mesh of 2½ inches; the latter, 25 yards long, 12 feet deep, with a 3-inch mesh. Although, undoubtedly, shad will bite at a hook in some of the northern rivers, the experiment has never been properly tried at Beaufort, to my knowledge. The average day's catch, in a fair season, for 200 yards of net is about 30 fish, but frequently is much less. The most favorable time of tide for fishing is low water, just at the time the fish are moving least.

The disposition made of this fish is as follows: but a small portion of the catch is eaten on the spot, as they command high prices, and it pays the fisherman better to dispose of them in the inland towns. Probably three-fourths are thus disposed of. It is considered the best food-fish that swims, and is eagerly sought for by all classes of people in its fresh state, smoked, and salted. In warm weather, although the flesh is fine and hard, after six hours decomposition rapidly ensues, rendering it unfit for food. Shad have always commanded at this point high prices, having been sold for $1.50 per pair, wholesale, although the average price is about 50 cents. These rates are a little higher than before the war. The supply of shad is so small about Beaufort that none are exported, the principal market being New Berne, N. C., and it is but seldom that fishermen feel justified in making any extensive preparations for its capture, most of those secured being found in the so-called herring-nets.

In view of the facts given above, I would hardly feel justified in recommending that any means should be taken to increase this fish in Beaufort Harbor, its inlets, and sounds; the geographical and natural advantages not being such as would justify either the expense or trouble, more particularly as the Neuse, which is not far distant, and communicates with the Newport River, has already been well stocked.

FORT MACON,

Beaufort Harbor, North Carolina, December 5, 1871.

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*Since the above was written the United States Fish Commissioner, Professor Baird, has thoroughly investigated the subject of the shad-supply of the southern rivers, and in 1873 placed in these waters a large number of young shad, hatched at New Berne, N. C., by Seth Green.

B—NOTES ON THE SHAD, AS OBSERVED IN THE DELAWARE RIVER.

By J. H. Slack, M. D.

1.—THE IMPORTANCE OF THE SHAD AS A FOOD-FISH.

Among the fishes of the eastern coast of North America the shad stands pre-eminent. From South Carolina to the Bay of Fundy they are found in every river, and the number annually captured must amount to many millions; the catch in the Delaware River alone, during the season of 1872, being at least two and a half millions.

2.—THE DECREASE IN THE DELAWARE.

The catch in the same river, however, varies greatly from year to year, and the reason for this is most probably as follows: Repeated experiments have shown that three years are required to mature the female fish, though the young males, called offal-fishes and rebel-shad, return during the second season. A heavy freshet during the period of spawning may bring down upon the spawn torrents of liquid mud, smothering the ova and destroying the life of the embryo fishes. The results of this will not be apparent until the third season. Unfortunately full and accurate statistics for a series of years are wanting, save in the case of one fishery, that of Dr. B. P. Howell, of Woodbury, New Jersey. This fishery has been in the possession of one family since prior to the year 1700, and a careful record of each haul of the seine has been kept. From this record it would appear that until the introduction of the gill-nets, 1820–'25, the catch averaged about 130,000 per annum.

Not to enter into detailed statements, but dividing the period between 1818 and 1873 into four cycles, each of which may be taken as representative of the intervening period, we have:

Average catch, 1818 to 1822, 131,000 per annum.
Average catch, 1845 to 1849, 66,890 per annum.
Average catch, 1865 to 1869, 60,739 per annum.
Average catch, 1870 to 1873, less than 25,000 per annum.

The season of 1873 did not pay expenses. But not only have these fishes decreased in numbers, but also in size. In 1843 shad of seven and eight pounds weight were by no means uncommon, and the average run was between five and five and a half pounds. Now in the Delaware River a four-pound fish is a curiosity. A catch is recorded as having been made near Burlington, New Jersey, in 1843, of three hundred and seventeen shad, averaging over six pounds each. Forty shad then filled a pork-barrel, mackerel-barrels not being in use. Over a hundred of the present deteriorated fishes are now required for this purpose.

3.—THE CAUSES OF DECREASE.

The cause of this is evident. The size of net-mesh in the river has been greatly reduced; only the smaller fishes can pass up the river

to their spawning-grounds, and from these puny parents nought but small puny offspring can be propagated.

The cause of decrease in the number of fishes taken can, I think, be placed under the following heads:

1. Erection of insurmountable dams: 2. Destruction of young fry: 3. Destruction of seed-fishes: 4. Destruction of spawn.

(3 *a.*) *Erection of dams.*—The erection of an insurmountable dam, cutting off parent fish from their wonted spawning-grounds, has been frequently followed by the total disappearance of the fishes from even the lower reaches of the river. A notable example of this took place upon the erection of the dam at Fairmount, Philadelphia. Before this large numbers of shad were taken in the reach of the river between the falls and its mouth. In a few years they had utterly vanished.

I am aware that it is the general belief that the fishes were driven away by the coal-tar thrown into the river from the city gas-works, but careful investigation has shown that shad-fishing was extinct several years previous to the construction of the gas-works.

A fish-way, capable of carrying shad, has long been a desideratum. Great hopes are entertained of the capabilities of that recently erected by Mr. Brackett at Holyoke, but the matter is still but an experiment.

Shad are taken in large numbers directly below the Lackawaxen Dam upon the Delaware; but few, if any, ascend beyond this point. However, in this case there are ample spawning-grounds below. Should any of the new plans for fish-ways now before the public prove a success the removal of these impediments is but a work of time.

(3 *b.*) *Destruction of fry.*—Few persons have any idea of the immense quantity of young fishes destroyed on their way to the sea. In our more northern rivers, with which I am best acquainted, the number devoured by carnivorous fishes is enormous. In 1870 a large number of young rock-fishes were examined, and in every case young shad were found in their stomachs. From one fish, eighteen inches in length, seven young shad were taken.

Fish-baskets destroy millions. In 1871 I made a careful and thorough examination of the upper waters of the Delaware River, for the purpose of investigating this point. The facts elucidated were astounding. It was ascertained that a scoop-shovel, with which to shovel out the dead young shad which accumulated in the basket, was an important part of the fishermen's equipment. One proprietor acknowledged that as much as a two-horse load of dead young shad had been shoveled from his basket during a single day. I am happy to state that through the active exertions of the fish-police these engines of destruction have entirely disappeared from the River Delaware, and I believe also from the Susquehanna, though they still abound in the more southern streams. The good effect of their destruction in the Delaware is already shown by the fact that the number of young shad seen descending that river during the past autumn has been far greater than ever previously noticed. Wing-

dams and water-power sluices, by carrying the young fishes into turbine-wheels and feeders of canals, carrying them into locks, where, as a witness remarked, they are *churned* to death by the rush of waters against the flood-gates, also contribute to destroy the fry.

(3 *c.*) *Destruction of seed-fishes.*—Under the name seed-fishes I would include parent shad during the season of actual spawning; in the latitude of 41°, it would be from June 10 to August 1. The capture of the parent fishes is, in most of our Northern States, strictly forbidden by law during this period, and the fishermen themselves are the most ardent advocates for its strict enforcement. The organization of a fish police in New Jersey has prevented any infraction of this law, even were the fishermen so disposed.

(3 *d.*) *Destruction of impregnated ova.*—As has been previously mentioned, a flood, by covering the ova with mud, may stifle them and prevent their incubation, but other and equally great dangers surround them. The number eaten by other fishes is enormous. I have fished much in the Delaware during the month of July, the height of the spawning season, and almost every sucker, minnow or cat-fish taken was found to contain shad spawn. I have seen suckers literally crammed with ova, so much so in fact, that upon holding them by the tail the spawn would flow from the mouth. The spawn of shad are peculiarily liable to depredations from these fishes, as, unlike the bass, sun-fish, and cat-fish, the nest, if nest it may be called, is not protected by the parents. By a special law of the State of New Jersey no net of any kind is allowed to be drawn in the Delaware River between June 15 and August 20, it being believed by the commissioners of fisheries of that State that the drawing of the heavy lead line of the net over the gravel-beds upon which the ova is deposited would destroy the vitality of the spawn. The great increase in the number of small fishes during the past few years has proven the truth of this theory. Seth Green has stated that in nature not two per cent. of shad-spawn will hatch, and this is proven by the comparatively small number of fishes in our waters in proportion to the immense numbers of ova annually deposited. The number of spawn deposited by a shad will average about forty thousand. Allowing but $\frac{1}{100}$ of one per cent. to return from the sea as adult fishes, and supposing the parent fishes to be entirely removed, the number of fishes in the river would be yearly doubled. Now, in fact, we know that they have been for some years past yearly diminishing, so that less than $\frac{1}{200}$ of one per cent. return as food-fishes.

4.—HABITS OF SHAD IN THE SPAWNING SEASON.

Though varying somewhat from year to year, the average date of the appearance of the shad in our waters is as follows, as far as I have been able to ascertain :

South Carolina, January; Norfolk, February; New York and New

Jersey,* March; Boston, early in April; Bay of Fundy, late in April or May.

It is the opinion of many fish-culturists that shad never spawn in tide-water. This, I think, is an error. Shad, so ripe that it was impossible to handle them ever so gently without causing a flow of spawn, have been repeatedly taken more than a hundred miles below the head of tide-water, and at Mull's Fishery on the Hudson, where millions of shad-spawn are annually taken, the tide ebbs and flows. From observations made by me at Camp Baird during the summer of 1873, it would appear that the ripe females with their attendant males feeling the time of spawning approaching, lurk during the day in the deepest portions of the river. At night, between an hour after sunset and midnight, they move into shallow waters, and, though for the proper incubation of the spawn clean gravel has been regarded as absolutely necessary, most ripe shad are taken upon bottoms thickly covered with aquatic plants. At Mull's Fishery so great is this growth of vegetation as to sometimes put a stop to the operations of the fishermen.

The noise of the splashes made by the fishes in the act of emitting the spawn and milt are the best guides for the fish-culturist in selecting a proper locality for a fish-camp, and the most favorable locations I have met with are on flats covered with aquatic vegetation in the immediate vicinity of deep reaches of the river. The splash, or wash of the shad, as it is termed by the fishermen, is apparently but a single sound, yet a carefully-trained ear can frequently distinguish two sounds, the second following instantaneously that of the first, being made by the male in the act of emitting the milt.

My attention was called to this second sound after observing the process of impregnation of the spawn of the gold-fish in a pond at my establishment at Troutdale. The male and female fishes swim side by side, the male generally upon the left with his head on a line with the dorsal fin of the female. Suddenly, on passing near a clump of aquatic plants, the female makes a leap out of water, throwing the whole body in the air, and scattering her spawn over the plants; she is immediately followed by the male, ejecting milt. So rapidly is this done that even while watching the process it is difficult at all times to distinguish more than one sound. Having frequently observed this, it occurred to me that the spawning of the shad might be similar, and observation has confirmed this impression.

The practical details and journals of my work having been presented in my previous report, I have, in the present paper, only given you my theories.

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* First shad taken in the Delaware Bay in 1874, February 10, an unprecedentedly early fish.

C—THE SHAD AND GASPEREAU OR ALEWIFE OF NEW BRUNSWICK AND NOVA SCOTIA.

By Charles Lanman.

1.—THE SHAD.

The shad of America, like the common herring, having been found to differ materially from the shad of Europe, has received a distinct name; the designation given by Wilson, and adopted by Dr. Storer, (*Alosa sapidissima*,) is here followed. Unlike most fish which frequent the northern seas, this species comes from the south to deposit its spawn.

At Charleston shad appear in January; at Norfolk in February; on the coast of New York at the latter end of March or beginning of April; at Boston in the latter part of April. In the Bay of Fundy they seldom appear until the middle of May. The first fish which arrive ascend the river Saint John to spawn; it is believed that they remain in the fresh water no longer than is necessary to deposit their ova, and then proceed up the Bay of Fundy to their favorite feeding-grounds, there to fatten upon the shrimp and "shad-worm" until they attain that degree of excellence which renders them so much sought after. The other shad, which are found in the autumn upon the same feeding-grounds, and in which no roe has yet been seen, are probably fish that have not attained a sufficient age for spawning, as those which ascend the river for that purpose are of large size and apparently old fish. The body of this fish is deep and compressed; its length varies from one to two feet. The width across the body, from the commencement of the dorsal-fin to the anal, is nearly equal to one-fifth the length of the fish. The usual weight of this fish is from one to four pounds, although it sometimes attains the weight of six pounds.

Of the sea-shad, none are so fine as those taken at the head of the Bay of Fundy, in the muddy waters of which they attain the highest perfection, owing to the great abundance there of their favorite food, the "shad-worm" and the shrimp. The shad is but rarely seen on the Atlantic coast of Nova Scotia. It is found in the Gulf of Saint Lawrence, the various rivers of which it ascends as far north as the Miramichi, which seems to be its limit in that direction, none having been seen in the bay of Chaleur.

The shad enters the Miramichi in the latter part of May, and remains until the middle of July; occasionally it ascends the Southwest as far as Boiestown, but the greatest numbers are found below the mouth of Etienne's River, always resting in deep, quiet water. The shad which frequent the gulf are greatly inferior to those taken in the Bay of Fundy.

The shad which ascend the Saint John resort for spawning to Darling's Lake, (Kennebecasis,) Douglas Lake, (Nerepis,) the Washademoac Lake, the Ocnabog Lake, the Grand Lake, and the Oromocto

River. They are caught in the Saint John, near Fredericton, but not above, the water being too rapid. The shad taken in the fresh water are very inferior to those which remain exclusively in the salt water of the bay, and the longer they are in the river the more worthless they become.

2.—THE GASPEREAU, OR ALEWIFE.

The alewife appears in great quantities in the Chesapeake in March; at New York it appears with the shad. The earliest fish appear in the harbor of Saint John in April, but the main body does not enter the river before the 10th of May. It would, therefore, appear that the alewife also comes from the south, like the common shad, to deposit its spawn in northern rivers.

The usual length of this species of shad, which is best known in New Brunswick and Nova Scotia by the name of gaspereau, is from 8 to 10 inches; the back a blue-green, approaching to purple; sides, silvery. The head, dark green above, and the tip of the lower jaw of the same color; opercles, yellow.

In the Bay of Fundy this fish is abundant; in the Gulf of Saint Lawrence it is less plentiful and of much smaller size; in the bay of Chaleur it has not yet been noticed, and, like the shad, the bay of Miramichi would seem to be its extreme limit north.

The catch of gaspereau in the harbor of Saint John varies from 12,000 to 16,000 barrels each season, and sometimes reaches 20,000 barrels. It ascends the Saint John to the same localities as the shad, in order to deposit its spawn. In the Miramichi it ascends to the source, and spawns in the Miramichi Lake.

APPENDIX D.

FISH-CULTURE.

(THE HISTORY, THEORY, AND PRACTICE OF FISH-CULTURE.)

XXI.—THE HISTORY OF FISH-CULTURE.

A—THE HISTORY OF FISH-CULTURE IN EUROPE FROM ITS EARLIER RECORDS TO 1854.*

By Jules Haime.

Fisheries have often been called the agriculture of the waters, as if seas, lakes, and rivers were inexhaustible store-houses of food, where, without fear of ever impoverishing them, man might continue to take and destroy forever, bounded only by his wants and desires. This definition is false, because founded on a false view of the case. Fishery is not the agriculture of the waters; it is only the harvesting. The waters are a source of production extremely powerful, but by no means infinite; and that the harvest may be always certain and abundant, it should be prepared by regular sowing, if it is true, according to the expression of M. de Quatrefages, that fish may be multiplied by sowing in the same manner as grain.

This would appear unnecessary pains, if we were to consider only the very great fecundity of almost all the aquatic tribes. A perch of moderate size contains 28,320 eggs, and a herring 36,960.

Thomas Harmer† and C. F. Lund‡ have obtained, by untiring researches, still higher numbers from other species, *e. g.*, 80,388 and 272,160 for the pike; 100,360 for the sole; 71,820 and 113,840 for the roach; 137,800 for the bream; 383,250 for the tench; 546,680 for the mackerel. A carp weighing 3 kilograms (66 pounds) contained, according to Petit, 342,140 eggs. A flounder has given the enormous figure of 1,357,400. There have been counted in a sturgeon as many as 7,635,200, and Leeuwenhoek has found 9,344,000 in a codfish. Finally, M. Valenciennes§ has just

*In the Revue des Deux Mondes, June 15, 1854, Paris, was published an article on Pisciculture, by Jules Haime, a translation of which, by Mr. Gamaliel Bradford, appeared in the Report of commissioners appointed under resolve of 1856, chapter 58, [of the legislature of Massachusetts,] concerning the artificial propagation of fish, with other documents, Boston, 1857.

As the most complete paper published on this portion of the history of fish-culture, and as a suitable introduction to the account of methods in use in the United States, it is here reproduced.—S. F. Baird.

† Philosophical Transactions Royal Society of London, vol lvii, p. 280, 1768.

‡ Memoirs of the Swedish Royal Association of Sciences, vol. xxiii, German ed., p. 192, 1761.

§ Valenciennes and Frémy. Researches on the composition of eggs in the series of animals. Academy of sciences, March 20, 1854.

calculated that there are 9,000,000 in a turbot of 50 centimeters, (19½ inches,) and as many as 13,000,000 in a thick-lipped mullet.

If only the tenth part of the germs inclosed in the body of each fish arrived at maturity, there must be little to fear from the devastation of our coasts, or the depopulation of our fresh waters; but numerous causes of destruction tend to reduce considerably the multiplication thus richly provided for. These arise partly from natural causes, but in great part also from the act of man. We are to point them all out, if possible, and weigh them successively before discussing the means of preventing their action, which will form the chief object of this article.

In the first place, we must not forget that, in the general harmony of nature, as Mr. Milne-Edwards has justly remarked, the productiveness of animals is regulated with a view not only to the dangers to which the young are exposed before ariving at the age of reproduction themselves, but also to the uncertainty of fecundation of the eggs. It is well known that the immense majority of fishes are oviparous, and that the fecundation is effected by the operation of the male element upon the female element separate from the body of the animals, and in the midst of the waters where they live. This action is the condition necessary to the development of the embryo, and all the eggs which have not experienced the contact with the animalcules of the milt change and soon decay. Now, it is never the case that all the spawn receives this action, and from this cause alone a portion, more or less considerable, is always lost. The portion which remains is in turn exposed to a host of pernicious influences. It may be left dry by a decline in the level of the water, or spoiled by the slimy substances which a rise of the water always causes and carries with it. The spawn has alse numerous enemies; many fish devour it, many crustacea, many insects attack it in like manner; it may be carried off by sea-weeds and byssus, and almost all aquatic birds are very fond of it.

All these chances of mortality and destruction prevent the fish from increasing as fast as the great number of eggs would at first lead us to suppose, but they are still in a measure subject to the laws of the animal creation, and would seldom suffice for the depopulation of the waters, unless supported by causes of another nature. Among these should be mentioned, first of all, the inadequacy of the legislation on the fisheries, and the violation with impunity of all the protecting ordinances which it has provided.

At the end of the last century Duhamel pointed out the depredations of the fishermen, who cast their lines, with impunity, at all seasons of the year, and daily suffer numbers of fishes, too small to be sold, to perish upon the banks. He saw, with natural indignation, the inhabitants of the coasts fill baskets with the spawn to manure their land or feed their swine. This culpable improvidence has still further increased, and we can almost say that, at the present time, all injuries are authorized and all abuses are practiced without limit. In vain the best-

grounded complaints are raised against the poachers upon fisheries: the devastations have continued on all sides.

The necessity has been felt, however, for a long time, of taking repressive measures against the destruction of spawn, and the historians of fishery have collected numerous ordinances, which have been successively issued with this view at different times and in different countries. Without citing them all, it will be sufficient to recall those which have had the greatest influence upon the legislation of the present time. In the year 966, Ethelred II, king of the Anglo-Saxons, interdicted the sale of young fishes. Malcolm II, in 1030, fixed the time of the year when the salmon-fishery should be permitted. Several other kings of Scotland have confirmed these decrees. Under Robert I, the willows of the bow-nets were to be separated by at least two inches of interval, to leave a passage for the young fry. In 1400, Robert III carried severity so far as to punish capitally every person convicted of having taken a salmon in the forbidden season. This cruel law was abolished by James I, but this prince kept up the interdict during the same season, and every infraction still remained the object of severe penalties. The kings of France were at great pains also to insure the free development of the young fishes. A great number of ordinances were issued by them, to determine the nature of the nets of which the use should be permitted, and the length of the fishes which might be sold in the market-places. At lengh, in 1669, Colbert placed upon a new footing the legislation of the coasts and rivers. He prohibited river-fishing during the night and during the spawning-season, under penalty of a fine of twenty livres and a month's imprisonment for the first offense, of a fine double in amount and two months' imprisonment for the second, and of the pillory and the scourge for the third. The only exceptions were in the fisheries of salmon, shad, and lampreys. Colbert also prohibited the placing of basket-wcrk at the end of the drag-nets during the spawning-season, under penalty of twenty livres fine; and after having determined the kinds of snares to be forbidden, he directed that the fishermen should return to the streams the trouts, carps, barbels, breams, and millers which they should take having less than six inches between the eye and the tail, and the tenches, perches, and mullets having less than five inches, under a penalty of one hundred livres fine.

The legislation which governs us at present is based upon the previous dispositions; unfortunately, it has disregarded the information offered by natural history, and thus but imperfectly attains the object proposed. The regulations relative to marine-fishing permit, for example, the taking of a given fish on shores where it has never been found, and give, for the limit of the crustacea, indications contrary to the most simple common sense. The code of river-fishing, which principally interests us here, is no better protected against criticism. The ordinance of November 15, 1830, supplementary to that of April 15, 1829, leaves to the prefect of each department the care of determining, with the advice

of the general council, and after having consulted the foresters, the times, seasons, and hours when fishing shall be prohibited in the rivers and water-courses. Now, how many times must the prefects, little skilled in natural science or ill-advised by those whose duty it is to enlighten them, have committed errors like those of Colbert, when he interdicted trout-fishing from the first of February to the middle of March, that is to say, at a time when they had nearly all already finished spawning! The same ordinance prohibits certain specified nets and snares, thus intimating that all others are authorized, and permitting changes of form and name in the first, without rendering them less formidable or destructive. Article 30 of the fishery-code punishes, with a fine of 20 to 50 francs, whoever shall catch, offer for sale, or sell fishes of less than the prescribed size, but it excepts from this provision sales of fish coming from ponds or reservoirs. It will at once be perceived how easy it is, through this exception, to catch and sell fishes of all sizes. Article 24 forbids the placing of any gate, structure, or fishing-establishment whatever, calculated to prevent entirely the passage of fish, but it tacitly authorizes dikes and mill-dams, which produce the same effect.

We will carry criticism no farther. It would be as easy for us to show that no efficacious measures insure the action of the fish-police, and that the law is as badly executed as conceived. This state of things is deplorable, and has, without doubt, powerfully contributed to bring on the decay which has fallen upon the aquatic industry of France.*

Some figures, taken from the archives of the ministry of finance, will show clearly the importance of the evil. The water-courses of France have a total length of 197,255 kilometers, (122,500 miles.) Its lakes, reservoirs, and fish-ponds occupy a superficies of 220,000 hectares, (900 square miles.) Now, the rent of all the waters directed by the commissioners of forests, and those of dikes and bridges, yields to the state a revenue of 660,000 francs. The former alone give fishing-privileges in 7,570 kilometers (4,750 miles) of navigable and floating water-courses, producing the annual sum of 521,395 francs; that is, an average of 69 francs to the kilometer. The insignificance of this sum is very striking when compared with what it ought to be, or even with that still furnished by some rivers more favored than others. Thus, the Doubs, in the Jura, is still let out at the rate of 159 francs the kilometer; the Moselle, in the department of La Meurthe, at the rate of 182 francs. For a similar length, the Loire brings in 252 francs in La Loire Infé-

*The evil has been further increased by the encroachments of manufacturing industry, as well as by the processes which they have involved. The mills throw off into the water-courses their acids and salts which have become useless, and the bleachers do the same with their chlorides. The beds of streams have often to be laid dry to execute dragging and cleansing. Finally, steamboats, by their violent movements of the water, raise and cast up the young fishes upon the river-banks, and these are often detained and perish there. These last causes of destruction are still more fatal to the development of the fry than the culpable practices of the poachers.

rieure, (department;) the Sarthe 297 francs in Le Mairie et Loire; and the Loiret 309. La Mayenne produces 339 francs, and the Seine 498. As for the Mairie, it produces the exceptional sum of 1,378 francs. By the side of these figures, more or less satisfactory, many others attest, on the contrary, the extreme scarcity of fish. The Ain, in the Jura, produces only 14 francs to the kilometer; the Dordogne, in the department of La Corrèze, 10 francs; the Isère, 8 francs; the Drôme, 4; and the Durance, 2. Finally, 219 kilometers have been depopulated to that point that they cannot be let at any price.

This marked inequality in the revenues of several rivers, which offer in general similar conditions to the fish, or whose different conditions can be differently improved, seems to indicate that the evil, even where greatest, is not irreparable. The proprietors, injured by the impoverishment of the fisheries, and the government itself more interested than anybody in the products of the rivers, have yet remained a long time inactive under the laws which they are sustaining. The remedy has been decided upon only after the reiterated solicitations of naturalists, who, long since masters of a process of artificial multiplication, have felt that it might be usefully applied to the repopulating of rivers and ponds. The first experiments have given results sufficiently remarkable not to discourage farther attempts. The practical methods have been promptly developed, and scientific researches skillfully conducted have impressed a new character upon pisciculture; that is, the branch of rural economy which is occupied with the improvement of waters. A very general interest is now felt in this important question of the artificial multiplication of fish, which belongs at once to the natural sciences, to agriculture, and to political economy. The result of the experiments which, since the end of the last century, have had for their object the restocking of rivers, already forms a curious chapter of zoological history; and while awaiting its increase by some new pages, it appears to us desirable to reunite its scattered elements.

I.

The first attempts at pisciculture were made by the Chinese and the ancient Romans, and it is probable that they were preceded by their elders in civilization. We have no positive data as to the epoch in which the Chinese commenced these experiments; but everything tends to show that they reach back to the most remote antiquity. We find in the "Histoire générale des voyages," (1748,) in Grosier, in Davis, as M. Chevreul has already pointed out, and in most of the works which treat of Chinese customs, some curious details on the transport of the spawn of fish. According to the missionaries who have visited China, a multitude of salmon, trout, and sturgeons mount into the rivers of Kiang-si and into the ditches which are dug in the middle of the fields to preserve the water necessary to the production of rice. They deposit their eggs

there, and the young, which are soon hatched, are a source of considerable profit to the riparian proprietors. The Jesuit father John Baptiste Duhalde, is the first French author who has shown* the manner in which this traffic is effected. We give his account, which most historians have copied with alterations: "In the great river Yang-tse-kiang, not far from the city Kieou-king-fou, in the province of Kiang-si, at certain times of the year, are assembled a prodigious number of boats for the purchase there of the eggs of fish. Toward the month of May, the country-people bar the river in various places with mats and hurdles for a length of about nine or ten leagues, leaving only sufficient space for the passage of the boats; the eggs of the fish are stopped by these hurdles. They can distinguish them by the eye, where other persons see nothing in the water; they draw out this water mixed with eggs, and fill several vases with it for sale, which causes, at this season, numbers of merchants to come with their boats to buy it, and transport it into different provinces, taking care to agitate it from time to time. They succeed one another in this operation. The water is sold in measures to all those who have fish-preserves and domestic ponds. After some days there are seen in the impregnated water, as it were, little heaps of fishes' eggs, without its being yet possible to distinguish the species. It is only with time that this appears. The profit is often a hundred fold more than the outlay, as the people live in great part upon fish." To these very simple but successful means of replenishing their ponds, the Chinese are said to have joined others which travelers have only very imperfectly indicated; they assert that when the young fish begins to eat, they give him marsh-lentils mixed with yellow of eggs.

The Romans had nearly similar customs at a very early epoch. "The descendants of Romulus and Remus," says Columella,† "rustics as they were, had much at heart the procuring upon their farms a sort of abundance in every thing like that which reigns among the inhabitants of the city; thus they were not satisfied with stocking with fish the ponds which they had constructed for this purpose, but carried their foresight to the point of filling lakes formed by nature with the spawn of fish which they threw into them. In this way the lakes Velinus and Sabatinus, as well as the Vulsmensis and Ciminus, have, in the end, abundantly furnished, not only cat-fish and gold-fish, but, moreover, all other sorts of fish which are able to live in fresh water." These practices were early abandoned, and it is a matter of surprise, when we consider the strange infatuation of which fish became the object in ancient Italy during the following centuries, that no measures were then taken to insure their reproduction and free development. It is well known that the ancients had a remarkable predilection for this species of food. The principal luxury of the Roman banquets consisted of fish, and the poets

*History of the Chinese Empire, vol. i, p. 35, 1735

†De Re Rustica, book viii, section 16.

speak of sumptuous tables spread with these exclusively. In the period between the taking of Carthage and the reign of Vespasian, this taste became a perfect passion, and for its gratification the senators and patricians, enriched by the spoils of Asia and Africa, incurred the most foolish expense. Thus Licinius Murena, Quintus Hortensius, Lucius Philippus, constructed immense basins, which they filled with the most rare species, and Lucullus, like a new Xerxes, caused a mountain to be pierced to introduce sea-water into his fish-ponds. Varro* relates that Hirrius received twelve millions of sesterces ($675,000) from the numerous buildings which he possessed, and that he employed the entire sum in the care of his fishes. The rich patricians, says the same author, were not satisfied with a single pond; their fish-preserves were divided into compartments, where they kept shut up, apart from each other, fishes of different kinds; they retained a great number of fishermen solely to take care of these animals. They tended their fish as carefully as their own slaves during sickness. It is even added that a naval expedition, commanded by an admiral, had for its object to introduce upon the coast of Tuscany a sort of scar peculiar to the water of Greece.†

This extravagant fashion, which spread through the various classes of society, and brought on the ruin of entire families, had also the effect of impoverishing the coasts of the Mediterranean. Ismeral complained that time was no longer given to the fish of the Tyrrhenian Sea to come to maturity. The scandalous luxury displayed in fish-preserves, and the unwearied attention then directed to marine-animals, have furnished no other result useful to pisciculture. The only fact worthy of remark at this epoch of sterile extravagance is the introduction of gold-fish into artificial ponds, where shell-fish were also placed for their nourishment.

We may pass rapidly over the immense interval which separates the Roman Empire from the eighteenth century, without remarking any important progress in the husbandry of the waters. The fisherman's art was, however, extended and perfected during the middle ages, and fish-preserves became extremely numerous in France and Italy. Kings and princes all had artificial ponds in their domains, and we behold Charlemagne himself taking great pains to keep his own in repair, causing new ones to be dug, and giving orders that the fish produced should be sold. The religious communities exacted enormous duties upon almost all fisheries, and had considerable preserves in which multitudes of fish grew fat. The maintenance of these preserves required many precautions, and the restorer of agriculture in the thirteenth century (Peter of Crescenza) pointed out the manner of getting the greatest result from the lakes of fresh as well as salt water. There appears in his work, however, no method worthy of being noticed here, and the

*De Re Rustica, book viii, section 17.

†For further details, see Noel de la Morimière, History of Fishes, vol. i, 1815; Cuvier and Valenciennes, Natural History of Fishes, vol. i, 1828; and Dureau de la Malle, Political Economy of the Romans, vol. ii, 1840.

treatise does not appear to us to have rendered any more service to pisciculture than that of Florentinus in the third century, at least as far as we can judge of the latter by the extracts which Cassianus Bassus has preserved for us. It appears, nevertheless, that toward the end of the middle ages new methods were sought for, which might serve to increase the production of fish; a monk of the abbey of Réome, near Montbara, named Dom Pinchon, conceived the idea of artificially fecundating the eggs of trout by pressing out in turn the products of a male and female of this species into water, which he afterward agitated with his finger. After this operation, he placed the eggs in a wooden box having a layer of fine sand on the bottom, and a willow grating above and at the two ends. The apparatus remained plunged, up to the moment of hatching, in water flowing with a gentle stream. This process is described in a manuscript dated 1420, and belonging to the Baron of Montgaudry, grand-nephew of our celebrated Buffon. It has never been published, and had remained secret till a recent time.* Dom Pinchon is then, in all probability, the first inventor of artificial fecundation; but his experiments must be looked upon as not having occurred, since they were not made public. They have, of course, had no influence on the progress of pisciculture, and are only interesting in a historical point of view.

The fishery of Commachio on the Adriatic, of which the origin is probably very ancient, presents some natural features, which may, perhaps, be imitated with advantage on other parts of the Mediterranean shore. Already described at length by Bonaveri, then by Spallanzani, this lagoon still merits that we should say some words with regard to it. It is, perhaps, one hundred and thirty miles in circumference, according to Spallanzani, and is divided into forty basins, surrounded with dikes, and all in communication with the sea. Eels abound there to such an extent that the inhabitants sell them through all Italy. During the months of February, March, and April, they leave the gates open and all the passages free; the young eels enter of their own accord, and the more abundantly in proportion as the weather is stormy. This they call the "mounting." Once in the basins, the fishes find nourishment so abundant and so well suited to their wants that they do not attempt to leave until full grown; that is, after about five or six years. The eels emigrate, and are taken in the greatest number during the months of October, November, and December. For this purpose the fishermen open at the bottom of the basins little passages bordered with reeds, which the eels follow from choice, and are conducted into a sort of narrow chamber, where they accumulate without being able to get out. On the average, the crop amounts annually to a million of kilogrammes, (2,204,737 pounds,) and M. Corte informs us that it produces, according

*M. De Montgaudry explained the hatching-box of Dom Pinchon at one of the last sessions of the Zoological Society of Acclimation, and was kind enough to inform us also of the manner in which the monk of Réome effected the fecundation of the eggs.

to the estimate of M. Cuppari, a net revenue of 80,000 Roman crowns; that is, about $88,000.

The fishers of Commachio profit, as we see, by the advantages which nature offers, and they have but few precautions to take to insure the development of the fish in this great preserve. The less favorable circumstances in which the fisheries of the Swedish lakes were carried on induced an investigation, toward the middle of the last century, of the means of preventing the considerable loss which the spawn had there to undergo. Already great care was taken in that country not to trouble the fish at the times of their reproduction, so that it was even forbidden to ring the bells during the spawning-season of the bream. A counselor of Linkoeping, Charles Frederic Lund,* remarked that the three species most esteemed among those which inhabit the lakes of that country, the bream, the perch, and the mullet, attach their eggs near the banks, either to the rocks, or, by preference, to the twigs of pine and to the willow cages placed in the water to catch them. The eggs are thus destroyed by the fisherman, or devoured by insects, birds, and especially the fishes of prey, so that hardly one out of ten finally escapes. He well understood that the prohibition of fishing during the spawning-season would very imperfectly prevent this enormous destruction. He devised another means of protecting the multiplication of the fish, which accords completely, as he himself remarks, with the habits of these animals, the mode and the laws of their reproduction, as well as with the rules of logic and of our own duty. He caused large wooden boxes to be made without covers, but pierced with little holes, and furnished with rollers, to allow of their descending easily into the water. He placed twigs of pine in them, and introduced a certain quantity of males and females, taken at the time of spawning, taking care to separate them by their kinds and to give them space enough. After having left them there two or three days—that is, during the time necessary for laying the eggs—he drew out all the fishes with the help of a small net, and arranged the boughs so as not to press too much against one another. The eggs arrived at maturity after a fortnight, or a little more, according to the degree of heat, and a multitude of young fishes came forth. This simple process included all the conditions necessary to success, and doubtless great advantages may be found in it for the propagation of fishes whose eggs are adherent. Lund succeeded in transporting from one lake to another boughs covered with spawn, which he placed in a vase of water, taking care merely not to expose them to contact with the air. In making a first application of his process, he had put separately into three large boxes, with a small number of males, fifty female breams, which gave him 3,100,000 of the fry; one hundred perch of the large species produced 3,215,000 of the fry; and one hundred mullets gave 4,000,000 of little ones. He obtained then in this manner more than ten millions

*Of the Planting of Fishes in Inland Lakes. Memoirs of the Swedish Academy of Sciences, vol. 23, 1761. German translation of Kartner p. 184.

of young fishes, which were dispersed in the Lake of Raexen. If this process had been employed on a large scale in all the lakes of Sweden, there would have resulted, says he, a real blessing for the country.

The favorable circumstances of the arrangement adopted by Lund enabled him to observe some particulars of the development of the embryo. A German naturalist, Bloch,* advanced somewhat farther in this direction by employing a similar means. He took from the Spree some aquatic plants covered with eggs of perch, bream, rotengle, &c., and kept them in a wooden box of fresh water, renewed daily. At the end of a week he obtained many thousands of little fish; observing, however, that only a small part of the eggs were fecundated, and that those which were so remained transparent and yellow, while those which failed became daily more disturbed and opaque. Bloch concluded that by transporting spawn upon plants, as he had done, lakes and ponds might be easily and cheaply stocked with fish; but he made no experiment, and, as we see, only imperfectly imitated Lund.

While the ingenious predecessor of Bloch was seeking the means of increasing the inhabitants of the Swedish lakes, a lieutenant of miltia of Lippe-Detmold, in Westphalia, J. L. Jacobi, conceived the idea of artificially fecundating the eggs of fish, and of applying this process to the repopulating of ponds and rivers. The curious results of his experiments were, indeed, embodied in a letter, which the "Magazine of Hanover" only published in 1763;† but as early as 1758 Jacobi had addressed manuscript-notes upon the subject to the illustrious Buffon, which Lacépède has mentioned in the first volume of his "Natural History of Fishes," and in the course of the same year he had intrusted another account of his labors to the Count de Goldstein, grand chancellor of Berg and Juliers. Goldstein caused a Latin translation of it to be made, which he sent M. de Fourcroy, director of fortifications at Corsica, and an ancestor of the celebrated chemist. This version was published for the first time in French in 1773, in vol. iii of the "General History of the Fisheries" by Duhamel-Du Monceau. Duhamel does not mention Jacobi; but, the facts in both memoirs being perfectly identical and set forth in similar terms, it is impossible not to perceive that both writings emanate from the same author. The date of the first communication entirely secures the claims of Jacobi, which are besides confirmed by the quotations of Lacépède, and by a communication made in 1764 by Gleditsch to the Academy of Sciences at Berlin. We give the details, because, the name of Goldstein alone having been printed in the "History of the Fisheries," many naturalists have wrongly attributed to him the merit of the discovery of artificial fecundations.

The experiments of Jacobi were upon the two most esteemed species

*Marc Eliezer Bloch, General and Particular Ichthyology, part ii, p. 94, 1795.

†It is to be found also, *in extenso*, in William Yarrell, History of British Fishes, vol. ii, p. 87, 1841; and at the end of Practical Instructions upon Pisciculture, by M. Coste, 1853.

of fish, the trout and the salmon. He tells us himself that, before arriving at good results, he had to employ sixteen years in preparatory researches and incomplete experiments. He remarked, in the first place, that from the end of November to the beginning of February the trout come together in the brooks and fix themselves upon the gravel, where they rub their bellies in a way which leaves large tracks. The females then deposit their eggs, upon which the males drop their milt. He caused some trout, then, to be taken at this season, when ready to spawn; taking by turns a female and a male, he pressed their abdomen lightly over a vase half filled with water, and let fall into it the mature products of both sexes, and then stirred up the whole with his hand, in order to render the mixture more complete, and thus to insure the fecundation of all the eggs. These eggs being once fecundated, it was necessary to combine the circumstances proper for their development, and for this purpose Jacobi thought of placing them in a grated box, across a little brook of running water. He constructed a large chest, at one extremity of which, and on the upper surface, he left a square opening, barred by a metallic grating of which the threads were separated by a space of only about four lines; this opening served to let in the water. Another, grated in like manner, and placed in the vertical face of the other extremity, allowed it to flow out. The bottom was overlaid with an inch of sand or gravel. Jacobi placed this apparatus in a trench prepared for it by the side of a brook, or, better still, a pond fed by good springs, from which he could cause, by a canal, an uninterupted stream of water to flow through the box.

These dispositions, very simple and judiciously combined, completely resolved the problem which he had proposed to himself, viz: To protect the fecundated eggs against their natural enemies and yet to leave them in circumstances similar to those in which they would naturally have been placed. The experiment succeeded. After about three weeks, Jacobi saw appearing through the thick envelope of the egg two black points corresponding to the eyes of the animal, and eight days later he began to distinguish the body itself, which moved and turned in the interior. Finally, after five weeks, the young fishes broke from their shells, and soon separated themselves completely from it, retaining only, under their bellies, a hanging yellow pouch, which is the umbilical vesicle. During nearly a month the young were nourished by the substance of this pouch, which disappears as they increase in size; but then they had need of other nourishment, and to obtain it they left the box by passing through the grating, and fell into a reservoir filled with sand and fitted to receive them. Jacobi adds that, in a basin of sufficient size, they grew wonderfully in the space of six months, and that then they had arrived at a suitable growth for stocking the ponds; but he does not say in what way he nourished them during all this time.

The inventor of artificial fecundation appears to have often repeated

the experiments which he describes, and took great pains to insure the success of them. He perceived that the eggs are easily spoiled when they get into heaps, and recommends, to avoid this danger, the separating them frequently by means of a switch. Care should be taken also that they do not stick together when the milt is poured over them. Finally, the dirt which the water deposits should, from time to time, be carefully removed from them, and this may be readily done with the feather of a quill.

The question now is, whether Jacobi, by neglecting no precautions, and guarding himself against the various chances of failure, did arrive at a final result which is completely satisfactory in a practical point of view. Did he succeed by means of his process in advantageously restocking water-courses which had become unproductive, or increasing production, to any extent, in those where fish were already abundant? We have not the requisite documents for answering this question positively; but we can scarcely doubt that he obtained at least partial results, since England recompensed his services with a pension, and in a little state of Germany his operations have been continued with success by M. Schmittger.*

Physiology soon turned to account the discovery of Jacobi, and artificial fecundations have since been frequently reproduced in laboratories. There is no need of recalling the results which Spallanzani, Prevost of Geneva, and Dumas have drawn from them. They have been also a great help to embryological studies; and by employing this means two contemporaneous zoologists, Rusconi and C. Vogt, have been able to follow all the phases of development of the tench and the palie; but this discovery especially marked a great progress in pisciculture, and, while science availed itself skillfully of this new mode of investigation, the practical results obtained by Jacobi were carried out in Germany and Scotland.

In the "Treatise on the Economy of Ponds," (by Ernst Friedrich Hartig, p. 411, 1831,) there is given a description of the process of Jacobi, with the remark that this method has been successfully employed by the forester, Franke, at Steinburg, in the principality of Lippe-Schaumburg, as well as by M. De Kaas at Bückeburg. The same facts are confirmed by M. Knoche,† who asserts that he has himself also completely succeeded upon the estate called Oelbergen. The last writer placed the young fish at first in a little reservoir, and the following year transported them into a larger basin. "I have obtained by this process," says he, "in the eight years that I have been employed, 800 young fishes out of 1,000 to 1,200 eggs. After a year I found in the smaller pond only about half the fish, the others having either died or escaped.

* This fact is proved by a letter of Dr. Schutt, of Frankfort, recently written to Mr. Milne-Edwards. The experiments of M. Schmittger have been made in the principality of Lippe-Detmold.

† Journal of the Agricultural Union of the Grand Duchy of Hesse, No. 37, p. 407, 1840.

Apart from this loss, they succeeded very well, and I have obtained in three years, out of the fish, in this manner, a crop of three to four hundred trouts a year, of three to four years of age, and of which the largest weighed three-quarters of a pound." M. Vogt, in a letter recently published, which reproduces this passage of M. Knoche, informs us at the same time that a decree of the government of Neufchatel, issued in 1842, gave complete instructions to the fishermen as to the method of artificially fecundating the eggs of fish.

Some experiments have also been made in England and Scotland. After having studied during several years the manner in which the salmon spawn naturally, Mr. John Shaw* attempted to combine the conditions which appeared most essential in some preserves which he caused to be made near the river Nith. These reservoirs were only two feet in depth, and spread with a thick bed of gravel. They were fed directly by the water of a spring, which abounded with the larvæ of insects. A close grating was placed before the conduits, by which the surplus of this water had to flow out to gain the river. These dispositions once made, Mr. Shaw fecundated the eggs just below the point where the water fell into his basins, and left them to develop at the same spot. This plan succeeded, and he was able to bring up a certain number of young salmon during two years, and even more. He took advantage of them to make observations upon their growth and change of color. At the age of six months the young salmon had a length of two inches; of a year, three inches and three-quarters; of sixteen months, six inches; and of two years, six inches and a half. At this last period, when they had put on the livery of emigration, and when they are called in Great Britain by the name of parr, the milt of the males had arrived at a sufficient state of maturity to be able to fecundate the eggs of adult females. We owe also to Mr. Shaw, as well as to Mr. Andrew Young† and Dr. Knox, our increased knowledge of various particulars relative to the monogamy of salmons, and to the maneuvres which the female performs on the spawning place, but these researches do not appear to have had any practical result worthy of attention.

An engineer of Hammersmith, named Gottlieb Boccius, published in 1848 a short treatise on the management of fish in rivers and streams. He extols in it the method of artificial fecundation, but without producing any positive fact to prove that he himself experimented with success.‡ Since that time he has assured Mr. Milne-Edwards that he had

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*Transactions of the Royal Society of Edinburgh, vol. xiv, p. 547, 1840.

† Natural History of the Salmon, Wick, 1848.

‡ In a previous work by the same author, (A Treatise on the management of Fresh-water Fish, with a view to making them a source of profit to landed proprietors, by Gottleib Bubocci London, John Van Voorst, Paternostêr Row, 1841,) there are directions, on page 19 for the propagation of trout by the method used by Lund, of confining a male and female in a box sunk in the stream.

It is very evident from this work that the author at the time of preparing his manuscript makes no claim to a knowledge of artificial fecundation.

operated in 1841 upon the water-courses belonging to Mr. Drummond, near Uxbridge, then upon the estate of the Duke of Devonshire at Chatsworth, upon that of Mr. Gurnie at Carsalton, and that of Mr. Hibberts at Chalfort. Mr. Boccius must have raised already about two millions of little trout.

The discovery of Jacobi had passed successfully, as we have seen, the trial and application in England as in Germany. Up to 1848, nevertheless, France had remained very much behind in experiments of this sort. Although she, perhaps more than any other country, had need of effectual means for remedying the impoverishment of the waters, the French economists had given scarcely any attention to this question. A single one, the Baron of Rivière, presented, in 1840, to the Central Society of Agriculture, some very learned and sensible reflections upon ichthyology regarded in its relations to the wants of man and the profits of agriculture.* He insisted especially on the advantages which would result from taking in the spring the *bouirons* or little eels which abound at the mouths of rivers, and dispersing them in the lakes, ponds, pools, and even muddy ditches, where they live very well. He satisfied himself that they might be transported alive in casks full of water, without appearing to suffer much from it; but wherever it should be possible to use rivers or canals, he thought it better to make use of boats pierced with holes in communication with the water, such as are frequently used for keeping fish. In this memoir of M. de Rivière, the word pisciculture is used for the first time; he employs it with hesitation to indicate this new branch of rural economy, which, says he, is still to be created.

II.

The year 1848 saw a new era commence in France for the economy of the waters. We believe it is just to say that if the application of artificial fecundation to the repopulating of rivers is owing to a German naturalist, it is in our country that pisciculture has grown, has been per-

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In his work published in 1848, (Fish in Rivers and Streams, a treatise on the production and management of fish in fresh water by artificial spawning, breeding, and rearing, showing also the cause of the depletion of all rivers and streams, by Gottleib Boccius, London, John Van Voorst, Paternoster Row, 1848,) after describing apparatus for the incubation and care of eggs he says, on page 32: "Six years have I successfully carried out this arrangement with trout in a fishery not far from London, which is now the richest stream in the south of England. The principle of artificial spawning I have been acquainted with as far back as 1815;" after which he describes the processes of artificial fecundation of eggs.

The statement made by Boccius to Milne-Edwards, repeated by M. Coste and subsequent writers, that he applied the art of artificial fecundation in England in 1841, seems to indicate an inconsistency with reference to the dates. The evidence from his first work has, of course, no bearing upon the matter other than to indicate that he had not practiced the art at the time of preparing the book. But his claim in his second book, that for six years he had practiced the art, would not carry him back to the autumn of 1841, unless it were the fact that the manuscript had been prepared more than a year before the date of publication.—J. W. M.

* Memoirs of the Central Society of Agriculture, vol. xlviii, p. 171, 1840.

fected, and has finally come to constitute an actual branch of industry. All the progress which has been made within six years in this department of the science is the work of French inquirers.

The first, M. de Quatrefages,* was led by purely scientific researches to occupy himself with the multiplication of fish. This zoologist, convinced that artificial fecundation would do away with the various causes which prevent the development of the eggs, advised the employment of the hatching-box of Goldstein (or rather of Jacobi) for fish of running water. For those of ponds or lakes he recommended depositing the fecundated egg on a layer of aquatic plants in a spot where the water should be tranquil and shallow, and protecting them by lattice-work against the attacks of their enemies. He showed how the employment of the process discovered by Jacobi would facilitate the domesticating of foreign fish in our waters. Finally, he pointed out the possibility of rendering annual the triennial and irregular product of the ponds by dividing them into three or four unequal compartments. In the smallest the eggs might be hatched and the fry raised. Each year the fish might be driven from one compartment to another, and the last basin might be fished every year.

The memoir of M. de Quatrefages made a good deal of noise, because it met one of the wants of rural economy, and gave a glimpse of a quite new prosperity for the industry of ponds and water-courses. Drawing from oblivion the results obtained in Germany during the last century, it recalled the attention of naturalists and husbandmen to a question too long neglected, and of which it would be now superfluous to dwell upon the importance. The author was, doubtless, far from thinking that the conclusions to which he had brought his studies would be almost immediately justified and confirmed by the experiments taken some years before, but which had not yet been made public. However, in the first days of March, 1849, the Academy of Sciences learned by a letter of Dr. Haxo,† secretary of the Society of Emulation of the Vosges, that this society had, in the year 1844, given a premium to two fishermen of La Bresse, MM. Rémy and Géhin, for having fecundated and artificially hatched some eggs of trout. M. Haxo added that Rémy and Géhin then possessed a piece of water containing five or six thousand trout, of one to three years old, all raised by this process. It is impossible not to admire the sagacity and perseverance of these fishermen, who, quite unlettered and ignorant of the progress of the natural sciences, have found the means of themselves, of remedying the decay of their industry, and of giving it a new impetus. Not only have they repeated, with great pains, the observations and experiments which occupied Jacobi's whole life, but they have gone much farther in the practical application, and have almost entirely resolved the problem.

* Comptes-rendus of the Academy of Sciences, vol. xxvii, p. 413, 1848. See also the Revue des Deux Mondes, Jan. 1, 1849.

† Comptes-rendus of the Academy of Sciences, vol. xxviii, p. 351, 1849.

Although they have both greatly contributed to the success of the undertaking, we now know that the first efforts were solely owing to Joseph Rémy, and that he associated Antoine Géhin with himself only after having already half succeeded. Rémy first studied the habits of the female trout ready to spawn. He saw them remove the gravel with their tails, and rub their bellies to assist the laying of the eggs. Having caught many of them in this state, he perceived that by pressing them a little with his hand, he could easily force out the mature eggs, and that the same thing occurred with the milt of the males. He next suspended a female above a vase full of water, and by means of a light pressure applied from above downward, he caused the eggs to fall out, upon which he afterward poured, in like manner, the fecundating liquid of the male until the water was white. Next depositing the eggs in a tin box pierced with numerous holes, and spread with a layer of coarse sand, he placed the box in a fountain of pure water, or in the bed of a brook; after a certain time he saw the young hatched, and freeing their tails first.

These facts, which Rémy relates himself in a letter addressed, in 1843, to the prefect of the Vosges, are, as we see, almost identical with those which Jacobi has embodied in his memoir, as these last were with the experiments of Dom Pinchon; but the two fishermen of La Bresse did not stop there.* It was not enough to have guarded the eggs against the chances of destruction, which menace them when abandoned to themelves. It was necessary also to insure the development of the young, and to find for them a nourishment suited to the wants of their age. This Rémy and Géhin succeeded in doing. After two or three weeks of a diet adapted to these wants, they opened the boxes which contained the fry, and allowed them to run freely into a water-chamber or a portion of the stream prepared to receive them. There they had taken care beforehand to raise a great number of frogs, of which the spawn is eagerly devoured by the young trout. Somewhat later they had recourse to the method already employed for the support, in preserves, of adult carnivorous fishes.†

Rémy and Géhin first stocked two ponds near La Bresse, several brooks of their canton, the water-courses of the commune of Waldenstein, and have thrown about fifty thousand young trout into the Mose-

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*Haxo d'Espinal on the Artificial Fecundating and Hatching of the Eggs of Fish, 2d edition, p. 22, 1853; and Guide of the Pisciculturist, 1854.

†"To nourish their young trout," says M. de Quatrefages, "they hatched with them other smaller species of fish, smaller and herbivorous. These are raised and nourished upon aquatic vegetables. In their turn they serve for food to the trout, who are nourished by flesh. These fishermen have thus succeeded in applying to their industry one of the most general laws, upon which are based the natural harmonies of the animal creation." In view of the necessity of their carnivorous diet, it is important to put together only trout of the same age, otherwise the smaller become the food of the large; and even with this precaution, it is not always possible to avoid the fatal effects of their voracity.

lotte, one of the affluents of the Moselle. These results were too important, and promised too great advantages in the economy of our waters, not to draw the attention of the public, and even of the government. In 1850 M. Milne-Edwards was officially charged by the minister of agriculture to make sure of the accuracy of the facts published, and to ascertain their value. After having procured some information in England as to similar experiments, he went into the Vosges, and visited the little establishment of the fishers of La Bresse. In a very remarkable report,* he gave an account of the interesting labors of Rémy and Géhin, and, while pointing out that the discovery of artificial fecundation dated back into the last century, he proclaimed that the fishermen of La Bresse were the first to make application of it among us, and that they have the merit of having thus created a new branch of industry in France. The learned dean of the Faculty of Sciences of Paris resolved upon a grand experiment of stocking the waters of France with fish and regarded the success of it as probable if the processes were judiciously arranged. It appeared to him that the best recompense which the government could make to the fishermen of La Bresse would be to give them the direction of the enterprise. The Philomatic Society did not hesitate to put forth a similar wish by the organ of M. de Quatrefages.†

The first notice of M. de Quatrefages, the promulgation of the success obtained at La Bresse, and the favorable report of M. Milne-Edwards gave a powerful impulse to pisciculture, and induced varied applications of it on all sides. Under the influence of these first labors, commenced, in many parts of France, the grand trial which is now going on. Its value will not be fully known till it is completed; but it is already sufficiently advanced to permit us to hope that in the majority of cases the method of artificial fecundation will produce important results. A certain number, both of eminent men of learning and of men of practical skill, have taken part in this movement, which, far from slackening, increases, on the contrary, and is extending daily more and more. Among those who have contributed most by their writings or their practical studies to the continually increasing progress of pisciculture, besides Rémy and Géhin, besides M. Milne-Edwards and M. de Quatrefages, we must mention M. Valenciennes, whose knowledge of ichthyology is so extensive and profound; M. Millet, inspector of waters and forests; M. Coste, professor in the college of France; Messrs. Berthol and Detzem, engineers of bridges and causeways; M. Paul Gervais,‡ at Montpellier; M. J. Fonmet,§ at Lyons; Mr. F. Defilippi,¶ at Turin.

M. Valenciennes|| has, at least in part, realized the hope which has

* Annales des Sciences Naturelles, third series, vol. xiv, p. 53, 1850.

† Journal of Practical Agriculture of June 5, 1852.

‡ Bulletin of the Society of Agriculture de l'Herault, July, 1852.

§ Memoirs of the Society of Agriculture of Lyons, May, 1853.

¶ Importanza economica dei pesci e del Coro allevamento artificiale.

|| Report on the Species of Fish in Prussia, which might be imported and acclimated in the fresh waters of France.

often been indulged, of transporting and domesticating in the waters of France the most esteemed fish of foreign countries. He has succeeded in bringing alive from the Spree to the reservoirs of Marly five different kinds, each represented by a certain number of individuals. There are the sander, (*Perca lucioperca, of* Linne) the wels or silure, (*Silurus glanis*, of Linne,) the Alandt, (*Cyprinus jeses*, of Bloch,) the German lotte, (*Gadus lota, of* Bloch,) and the pitzker (*Cobitis fossilis*, of Linne.) This trial has only been made on a small scale, but it is none the less important on that account, since it proves that, in ordinary circumstances, difference of waters would not be an absolute obstacle to the acclimating of foreign fish.

The same gentleman was afterward charged by the minister of marine with the duty of inspecting the fisheries of our coast. The report, in which were embodied the observations made in the course of this mission, has remained unpublished, and it is to be regretted that the learned ichthyologist was not able to continue and extend these researches, to which his previous studies so naturally called him.

It is worthy of notice what wise circumspection MM. de Quatrefages and Milne-Edwards have employed in presenting the advantages which rural economy might derive from the method of artificial fecundation. They have incited the proprietors to attempts which appeared likely to be advantageous, but without always promising them certain results. M. Coste has proceeded with less reserve. With unlimited confidence in the future of pisciculture, he has allowed no occasion to pass without exalting the benefits which it will confer. In his first report, at the close of the year 1850, he declared already "that there is no branch of industry or husbandry which, with less chance of loss, offers an easier certainty of profit."* Later he speaks with enthusiasm of the means tried during a century of providing for the repopulating of the waters. Most certainly it is with excellent intentions, and, doubtless, in the hope of sustaining the efforts of experimenters, that M. Coste thus undertakes to guarantee future results; but is it not rather to be feared that, in magnifying too greatly some partial successes, he may compromise the general success of the undertaking? Meanwhile, though these absolute affirmations seem to justify, to some extent, some criticisms of which the learned professor has been the object, they cannot diminish his share in the improvements recently made in the method of Jacobi.

M. Coste first put in practice the means proposed by the Baron de Rivière for transporting the "mounting" or the young eels, and raising them in confined spaces.* After having brought this mounting from the mouth of the Orne to the College of France, in flat paniers, overlaid with aquatic plants, he gave them for nourishment a hash composed of the flesh of animals, which do not serve for food or that of

* Practical Instructions upon Pisciculture, p. 34.

molluscs and earth-insects. The little eels, which, on arriving, had an average length of six and seven centimetres, (two and one-half to three inches,) and a circumference of one centimetre, had arrived, after twenty-eight months of this diet, at thirty-three centimetres of length, and seven of circumference. M. Coste remarks with reason that the corpses of the vertebrated animals, which are not fit for the food of man, might be made useful in this manner. He adds that the noxious insects would serve quite as well to fatten the fish. "Thus a great service would be rendered to agriculture, since it would, in the end, be delivered of one of its s ourges." It is to be regretted that the learned professor has not entered into any details upon the best method of capturing these insects, which the cultivators have so great an interest in getting rid of, even if they could not make a profitable use of them.

The author of the Practical Instructions upon Pisciculture has been at length induced to take charge of the organization of a vast establishment of artificial fecundation. In 1850 the two engineers of the canal from the Rhone to the Rhine, Messrs. Detzem and Berthol, after having visited La Bresse on the invitation of the prefect of the Doubs, had applied at Huningue the method of Rémy and Géhin. Upon the basis of their first experiments they had undertaken hypothetical calculations, from which it appeared that the present population of the waters of France does not exceed twenty-five millions of fish, producing annually less than six millions of francs ($1,200,000)—which figure is really much too large—while, if the process of artificial fecundation were everywhere introduced, the number of fish would be raised, after four years, to three thousand one hundred and seventy-seven millions, and would produce a revenue of nine hundred millions of francs ($180,000,000.)* At Lochlebrunn, some kilometres from Huningue, MM. Detzem and Berthol had established the foundations of a large preserve, where in 1852 they operated numerous fecundations by means of a hatching-box which in no respect differs from that of Jacobi. They assert that they have there obtained a cross of the trout and salmon.†

The minister of agriculture directed M. Coste to visit the new establishment. In a report, favorable to the labors of MM. Berthol and Detzem,‡ the professor of the College of France asked for and he succeeding in obtaining a considerable development of the fish-preserve, or *piscifactory*, as he proposed to call it. He brought into use on a large scale a hatching-apparatus, which we shall have to describe, adopted all the measures which he thought most fit; and in his memoir upon the means of restocking the waters of France, he undertook, before the Academy of Science, to make a delivery in June, 1853, of six hundred thousand trout and salmon, large enough to be thrown into our rivers. We have not visited the establishment of Huningue, and know

* Artificial Fecundation of Fish: Society of Emulation of the Doubs, p. 18, 1851.

† Report upon the facts proved at Huningue from May 8, 1851, to May 7, 1852.

‡ Practical Instructions in Pisciculture, p. 96.

not whether it is organized in a way to fulfill a part of the promises which its founders have often put forward; but from the information which has reached us from several quarters, it would seem that their success has not always been as complete as was hoped for at first. It is then much to be feared that after four years, and even more, the establishment of Huningue will not have succeeded in alone restocking with fish all the waters of France, and in making them produce the nine hundred millions of francs promised by MM. Berthol and Detzem.

However this may be, the relations established between this piscifactory and the College of France have furnished to M. Coste an opportunity of making some curious observations on the transport of the eggs, and the duration of their vitality after having been taken from the water. Some eggs of salmon and trout, sent from Mulhausen by the diligence, were hatched in great numbers at the College of France. The precaution had simply been taken of surrounding them with moist aquatic herbs in a tin box pierced with holes on the upper side.* Other eggs, artificially fecundated, arranged in layers with wet sand in a pine box, remained thus two months in a cold chamber. At the end of this time they were only corrugated; but having placed the box in water to moisten them through the sand, M. Coste saw them soon resume their natural appearance, and they hatched soon after.

To render possible in his labratory the experiments which he had undertaken, M. Coste had to adopt an apparatus occupying but little space, and for which a simple thread of water would suffice. The arrangements which he chose are very simple. This apparatus, which, by the way, we have often seen in operation, is an assemblage of little troughs arranged like steps on each side of an upper trough which serves to supply all the others. The bottom of each trough is covered with a bed of gravel. A stop-cock lets fall a continuous thread of water into one end of the upper trough. A current is thus created toward the other end, and there an opening at the sides giving it passage to right and left, it breaks into two falls of water which go to feed the two troughs placed immediately below. These last have also openings by which the water falls into the lower troughs, the number of which may be increased at pleasure.

After the hatching obtained by this apparatus, M. Coste was able to inclose two thousand young salmon into a canal of baked earth, having fifty-five centimeters in length, (twenty-one inches,) fifteen in breadth, and eight in depth, where, says he, the current is kept up by a simple thread of water of the size of a straw. He gave them for nourishment a paste formed of muscular flesh reduced to fine fibers, in preference to the boiled blood of which Rémy and Géhin had made use. A salmon raised in this manner in an artificial pond two meters in length, (eighty inches,) and fifty centimeters in breadth, (nineteen and one-half inches,) was, at the age of six months, larger than those of the same age taken

* Comptes-rendus of the Academy of Sciences, vol. xxxiii, p. 124, 1852.

in the Scottish rivers, and represented in the work published under the assumed name of Ephemera.* Such are the principal results to be ascribed to M. Coste. He has recently collected his memoirs and reports into a volume, under the title of "Practical Instructions upon Pisciculture." He sets forth in these instructions the knowledge previously acquired, and those which he has drawn from his personal experience, and he adopts some of the improvements introduced by M. Millet in the practice of the new industry. We regret that the author of this little work, written with much elegance and clearness, has not oftener cited the sources from which his information is taken.

The same day upon which M. Coste presented his work to the Academy of Sciences, M. de Quatrefages read before this learned body some researches upon the milt of certain fresh-water fish.† The question here treated of is fundamental; and before it had been resolved, it was impossible to use the necessary precision in artificial fecundations. This labor is then of great importance in the double point of view of comparative physiology and the application of zoology. We know by the experiments of Prevost, of Geneva, and of M. Dumas, that the milt owes its physiological properties to the presence of animalcules, which move in a manner very peculiar, and that all fecundating-power disappears the moment that these animalcules die. Now, M. de Quatrefages shows that the duration of these movements is extremely short in the case of fish, even in the most favorable circumstances. Thus, in the milt of the brochet, diluted with water, all vitality ceases after eight minutes and ten seconds; the animalcules of the mullet are all dead after three minutes and ten seconds; and those of the carp after only three minutes. This period of activity is still more limited for the perch and barbel, since it only reaches two minutes forty seconds for the former, and two minutes ten seconds for the latter. Neither is it equal for all the animalcules of the same fish, and half of them perish in much less time. Besides, the preceding figures are taken at the degree of heat most favorable to the duration of these movements, and even slight variations above or below this point destroy them with great rapidity. The temperature which maintains longest the vitality of the animalcules is, for winter-fish like the trout, forty-one to forty-eight degrees of Fahrenheit; for those of the early spring, fifty to fifty-five degrees; for those of later spring, as the carp and the perch, sixty-three to sixty-eight; and for the summer kinds, seventy-seven to eighty-seven. When the temperature somewhat exceeds these limits the increase of energy on the part of the animalcules compensates, to a certain extent, for the shorter duration of their vitality. These results apply to those which are disseminated through the water; when they remain united in small

* The Book of the Salmon, by Ephemera, [E. Fitzgibbon,] assisted by Arthur Young. See also the Agronomic Annals, vol. i, p. 234, 1851.

† Comptes-rendus of the Academy of Sciences, session of May 30, 1853, vol. xxxvi, p. 936; Annals of the Natural Sciences, third series, vol. xix, p. 341., 1853.

masses they die much more slowly. The peculiarities of the milt may thus be preserved for a much longer time when it is not diluted, and especially when it is kept at a very low temperature. It may even be frozen without causing in all cases the death of the animalcules. "M. Millet, who has aided me in all these researches," says M. de Quatrefages, "has thought of putting the milt with ice into a tin box, so that the water may run out as the ice melts, and then to arrange this box in a second wooden one, pierced with very small holes, and itself filled with ice." Thanks to these precautions, the learned academician has been able to preserve the milt in a serviceable condition during sixty-four hours. It is worthy of remark that the fecundating-property disappears first in that part of the male organ where the liquid is most completely elaborated, and endures some time longer in the deeper parts.

These facts taken together will explain most of the failures resulting from operations apparently well conducted. They show that the manipulations must be accomplished with great quickness, and careful attention must be paid to the temperature of the water. We may conclude from them also that the season of spawning in certain localities must vary in accordance with the atmospheric phenomena; that the short vitality of the milt is one of the causes which oppose the crossing of the different species in nature; and that the hitherto unexplained instinct which leads the trout and salmon to mount to the sources of water-courses is owing to the need felt by these animals of finding a degree of temperature suitable to the fecundation and development of their eggs. M. de Quatrefages has also deduced from his researches data of great value for practice, and eminently suited to regulating the methods of artificial fecundation.* The results contained in the memoir of M. de Quatrefages give to these methods a scientific regularity, which they have wanted hitherto, and tend to endow pisciculture with fixed and precise rules.

To complete the summary picture of the progress which pisciculture has made from antiquity to our time, and to show its present condition, it remains to point out the numerous and important improvements which are owing to M. Millet, inspector of waters and forests.†

* Since the male liquid, completely elaborated, loses first its fecundating-properties, only that should be used in doubtful cases which is pressed from the milt itself. The vitality of the animalcules not being destroyed by cold in the male organ, the frozen milt is not to be rejected as useless. If the fecundation cannot be made till after the death of the animal, it is well to take out the milt and preserve it in a wet cloth. In view of the extreme shortness of life of the animalcules, and of the obstacles which the swelling of the envelope may oppose to fecundation, it is useful in the case of certain species to pour the eggs and the male product simultaneously into the same vessel, and thus to render the contact instantaneous. Of course, the water must never be first impregnated with the milt.

† Report to the director-general of waters and forests upon the repopulating of the navigable and floating water-courses, by M. de Saint Ouen, administrator of the forests, March, 1853. Annals of the Forests, pp. 272 and 429, July and August, 1853. Independently of the various memoirs upon pisciculture which we have hitherto cited, it

It is a well-known fact that fish do not deposit all their spawn at once The eggs do not all arrive together at a state of maturity. When left to herself, the female returns several times to the place of spawning, where the male always follows her, and it is only after a certain number of days that the delivery of the eggs is complete. Although it has been already remarked that only the ripe eggs leave the ovary and find their way into the abdominal cavity, yet the advice was always given to effect the artificial fecundation at once by forcing out the spawn by pressure on the sides of the belly of the female. Without doubt, this practice, in many cases, was attended with a violence as injurious to the development of a great number of the products as to the health of the animals thus operated upon.

Struck with these inconveniences, and convinced of the advantages always following from a strict imitation of nature, M. Millet took pains to gather the eggs only in portions and in several days, as they became completely ripe, and to let them fall into the water simultaneously with the milt of the male. As captivity has often a bad effect upon the generative functions of fishes, M. Millet only takes them at the moment of making the fecundations, and restores them to the river immediately after, at the same time tethering them with a pack-thread passed through the gills. They live very well in this condition, and do not perceptibly suffer from it. M. Millet has also sometimes made use of artificial spawning-holes, which call to mind those of Lund, but are more perfect. These are a kind of double-bottomed cages, the first consisting of an open frame-work of bars, the second of a movable sieve of metallic cloth. The females, by rubbing against the bars, let fall their eggs, which drop upon the sieve. The males being introduced into the apparatus at the same time, it generally happens that the fecundation is effected naturally. This method of gathering has the advantage of losing no portion of the eggs, while there is risk of this in holding the female by a cord in rivers.

The hatching-apparatus used by M. Millet varies a little with circumstances, but remains always simple, convenient, and economical. If the development of the egg is to take place out of the water in which the parents live, whether in an apartment or under a shed, a vessel of any description is taken, having a capacity of thirty to thirty-five litres,

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may be useful to consult the report of a commission of the King of Holland, having for title, "Handliedung tot de kunstmatige Veremenigouldigen van Vischen, 1853;" some notes of M. de Camnont in the Norman Annual for 1850, and in the same collection an Essay upon the Multiplication of Fish in the department of La Manchi, by M. G. Sward de Becunlieu, 1854, as well as some letters of the Marquis of Wibraye and the Count of Pontgibard, 1854; in the Analytic Sketch of the Labors of the Academy of Rouen, a note by M. Bergasse on Artificial Fecundation applied to the Salmon, 1853; and some Researches into the Natural History of the Salmon, by M. A. de Bignon, 1853; finally various observations of MM. Géhin, Richard de Behagne in the Bulletin of the Agricultural Society of Paris, vol. vi, pp. 461 and 469, 1851; of M. Noblet, ibidem, vol. vii, p. 403, 1852, and M. Quenard, ibidem, vol. viii, p. 95, 1853.

(eight to nine gallons;) and on the bottom of this gravel, sand, and charcoal are heaped up so as to constitute a filter. A purified water runs from this reservoir by a stop-cock situated underneath it, and falls into troughs placed like steps, which may be multiplied at pleasure. This arrangement is entirely similar, as we see, to that which M. Coste had already chosen; but M. Millet has added an improvement, which, we hasten to say, the learned professor of the College of France has at once adopted in his turn.

However pure running water may be, it always bears with it and deposits at the bottom which it covers foreign particles, which, if they rested upon the eggs, would finally surround them with a sort of slime favorable to the development of byssus and mold. To meet this objection, M. Millet thought of suspending the eggs a little below the surface of the water. M. Vogt* had already taken the precaution to place them in a muslin bag, permeable on all sides, which he threw into the lake after having fastened it to a stake, or kept it in place by a large stone. Starting upon the same principle, M. Millet has arrived at a surer and more complete result. He places the eggs upon sieves, which little rods, sliding on the edges of the tubs, hold at the desired height. This skillful experimenter has successively employed sieves of various substances, of hair, of silk, of willow, &c., and has finally given the preference to galvanized metallic cloth, which have more solidity and durability, do not spoil, are easily cleaned by the help of a brush, and are only very rarely attacked by sea-weed.

The expense of outfit of such an apparatus is quite insignificant. The working consists merely in filling the reservoir every morning and evening, in moving the sieves once a day, and taking away the eggs which may become opaque. For many years the eggs of trout, of salmon, of the umber, &c., have been developed in this way, and hatched in considerable quantities in the same apartment which the experimenter occupies at Paris, in the middle of the rue Castiglione.

When the process can be carried on in the water of a stream itself, of a lake, or of a pond, M. Millet recommends the employment of double sieves of metallic cloth, which may be kept at a suitable height by the help of floaters, and which follow all the changes of the level of the water. For the species which spawn in sleeping water, he lines the double sieve with aquatic plants, or limits himself to placing the eggs in large shallow tubs with plants, which prevent the water from corruption. When the fecundated eggs are to be transported to great distances, M. Millet advises placing them in a flat box, in quite thin layers, between two wet cloths. In this state he has sent them to Florence, where they have reached the hands of M. Vaj and the Professor Cozzi, after a journey of twenty or twenty-five days, and have not failed to hatch soon after. The use of moist linen is preferable to that of aquatic

* Embryologie des Salmones; Histoire Naturelle des Poissons d'eau douce de L'Europe centrale, by L. Agassiz, p. 16, 1842.

plants; the linen dries less rapidly, and facilitates the unpacking, which, in the other cases, requires much time and care. The Marquis of Vibraye, to whom the Sologne owes so many useful improvements, and who has already introduced on his estates numerous trout produced by artificial fecundation, has also made use, with advantage, of small wadded cushions. When the eggs to be dealt with are very delicate, and are to be transported during the summer, M. Millet sometimes employs the little portable ice-box, of which we have already given the description.

As soon as the young fish have completely absorbed their umbilical vesicle, that is to say, some weeks after the hatching, the author of these curious experiments is of opinion that it is best not to try to nourish them in captivity, but to dismiss them at once into the waters where they will have to live, taking care, however, to place them suitably where they will find the spawn of frogs, lymneas, planorbis, &c. They should commence at once to seek for their prey, and thus avoid the suffering from change of water, of nourishment, and of habits, to which they will necessarily be subject, if raised artificially in basins not communicating with the waters which they must inhabit.

It is principally in the departments of the Eure, the Aisne, and the Oise that M. Millet has put in practice these various methods. Affidavits emanating from the local authorities bear witness to the important results which he has obtained. M. Millet has conducted, at the same time, a series of delicate observations, which have already led to some happy applications.* He has examined the action of salt or brackish water on the eggs of fish which leave the sea to spawn in fresh water, and he has seen that it is injurious to their development in ordinary cases, which gives the practical reason of the emigration of these animals. Nevertheless, salt, which would destroy the healthy eggs, has the singular property of healing them when attacked by white spots. These spots, which probably spread from the surface to the center, and would lead to the destruction of the eggs if allowed to increase, disappear in water very slightly salted; and when they are taken in time, the young fish may thus be saved. It results also, from the observation of M. Millet, that the mortality of the eggs always reaches its maximum at the epoch when the embryo begins to form; accordingly he advises transporting them only when the eyes become visible, or rather immediately after the fecundation. He has remarked, finally, that the white spots on the one hand, and the sea-weed and byssus on the other, attack much more rarely the eggs of trout and salmon, at a low temperature, than in one which exceeds fifty-four degrees.

Here terminates the rapid exposition of the applications furnished by zoology to the economy of ponds and water-courses, and of the prog-

* Comptes-rendus of the Academy of Sciences, vol. xxxviii, session of December 26, 1853.

ress which this branch of industry has made of later years. The labors of Rémy and Géhin, and those of M. de Quatrefages, of M. Coste and M. Millet, represent the present state of this department of agricultural science. To them belongs the honor of having regulated and perfected the methods, and of having determined the basis of a cultivation before very vague and precarious.

III.

The processes which we have analyzed are not all equally adapted for easy and profitable application. It remains then to compare the respective advantages of them, to determine the combined measures which pisciculturists ought to adopt.

The first care to be taken when it is desired to stock a river or pond is to learn what species of fish will best adapt themselves to the circumstances which happen to be united there. To escape the danger of certain failure, it is first of all necessary that the nature, the ordinary temperature, the depth, and the various qualities of the waters to be enriched should agree with the instincts, habits, and way of life of the animals to be developed there. These recommendations are found in all books upon the subject, but cannot be too often repeated. It is most certainly from the neglect of these proprieties, and want of appreciation of them, that certain pisciculturists have seen their attempts miscarry when they were otherwise skillfully executed.

When, therefore, the ground, as it were, has been studied in advance, and it has been determined what sort of fish has the best chance of prospering there, the individuals necessary for the multiplication of the chosen species should not be procured except at the very season of spawning, since very often the products are spoiled in the bodies of fishes which are condemned to close captivity. This inconvenience does not present itself if the animals can be placed in reserve in inclosures near the rivers or ponds in which they have been caught. Otherwise they may be held by a cord in the same places where they have lived. It is important, before effecting the fecundation, to pay attention to the temperature of the water, which has so great an influence upon the properties of the milt, as M. de Quatrefages has so clearly shown, and probably also upon the vitality of the egg itself. Although M. Vogt has seen the eggs of the palee* prosper after they had been taken in ice, this extreme cold is generally sufficient to destroy them.

The gathering of the male and female elements should be made on different occasions and in several days. It seems useful, in many cases, to guard the products from all exterior influences, and not to take them from their natural medium. For this purpose a male and a female are taken and inclined near each other at the surface of the water. They are then bent gently upward, which produces a strong contraction, and

* A species of white-fish (*Coregonus palea.*)

generally serves to create a flow of the ripe products. If the exit offers any difficulty, it may be assisted by passing the finger under the belly but without any effort.' The simultaneous or almost simultaneous mixture of the eggs and the milt is necessary in most cases, since with certain fish, as the trout, the animalcules of the milt do not live even a moment, and with others, as the carp, the mucilaginous envelope of the egg swells rapidly in the water and, then opposes itself to the impregnation. For the last reason, it is important always to refrain from washing the eggs before fecundation, as some persons had advised doing.

The eggs once fecundated are placed in an apparatus like those of M. Coste and M. Millet; but it appears to us preferable in all cases, when possible, to employ the double sieve or floating insulator of the last experimenter. The fecundation is then effected in the lower part of the sieve, placed in a tub full of water; and after the cover is put on, the whole is transported to the river which is to be furnished: in this way the spawn undergoes no change of water, from its exit from the belly of the female to the period of its development. If the eggs are unencumbered, they are allowed to fall to the bottom of the sieve. If they are adherent, likes those of the carp, the tench, or the barbel, care is taken to introduce beforehand into the sieve some aquatic plants or twigs. The little apparatus is furnished with floaters, and fastened to stakes by a cord, by which it is easy to draw it to the bank, when it is to be examined. After the young fish are hatched, and their umbilical vesicle is completely absorbed, the sieve is opened, and they are thus dispersed in the very places where they are to live. With this view, shallow places are chosen, which the fry generally prefer, and which are not frequented by the large fish, or rather inclosures near the water-courses. The fish of this early age have great agility, and commonly escape the pursuit of their enemies by squatting among the pebbles, and concealing themselves in the grass or the roots of trees. They then feed naturally upon lymneas, planorbis, small worms, or the spawn of frogs, but it soon becomes useful to throw them the refuse of the shambles or the kitchen, and, generally, as M. Coste has advised, all animal substances which are not made use of. It would seem, however, that some of these substances may become injurious to the fish, and M. Sivard de Beaulieu has remarked that his trout always died after eating earth-salamanders. The putrefaction of the substances which are not eaten offers no inconvenience in a mass of water frequently renewed like that of a brook, while for this reason, and many others, the artificial nourishment of young fish in narrow reservoirs is almost impracticable. They should, therefore, always be dispersed after the absorption of their vesicles, without attempts to raise them painfully in small apparatus.

These various operations are, as we see, very simple and easy, and may be brought to a good result by anybody with little outlay of time and expense; but it is evident that success depends greatly upon the tact and foresight of the operator, and that here, as in all branches of indus-

try, individual skill will always have great influence upon the result. Without doubt, also, a prolonged and sufficiently extensive experience will soon attain to further improvements in the application of the new methods, and reduce greatly the chances of failure. Everything, then, gives reason to hope that at an early period pisciculture will be naturalized among the useful sciences, and that it is destined to solve one of the important terms of the great problem of cheap living.

This result, so desirable, would be greatly expedited if the Government should decide to take some energetic measures. It should cause to be completely revised, by competent men, the legislation of the fluvial and marine fisheries, and should bring the system of artificial fecundation into operation in all the fresh waters of France, at the same time that a service of observation and vigilance should be organized upon our coasts. In uttering this wish, we are only the echo of all the learned men and economists who have touched upon this question.

Already, indeed, the state has made a first step in the path where we should like to see it wholly enter. It has decreed the piscifactory of Huningue. We are far from denying the services which this establishment may render by its consequences; but it is clearly proved that it will never suffice for entirely restocking the waters of France, and meets very imperfectly the present wants of pisciculture. If there are too great obstacles to putting this vast trial in practice over the whole surface of the country, it would at least be easy for the state to undertake it in more limited though still considerable proportions, and without charging the budget with any new burden. For this purpose it need only profit by the resources offered by the administration of waters and forests. In fact, this administration disposes of a surface of canals and brooks which reaches nearly 8,000 kilometers, (5,000 miles,) and has a personal force quite ready and trained to the various practices for the husbandry of the waters. The number of its simple fisheries police amount to 427, without counting the general police, sub-inspectors, and inspectors which direct the others, and who are all prepared, by their previous studies for applications of this kind. Here is a service extensively organized, which would be admirably adapted to experiments of pisciculture on a large scale, and which would not, even thereby, be turned from its legitimate functions.

It is to be hoped that those who are interested will not fail to be struck with these easy advantages, and that they will try to attain to at least a part of the results promised by the new industry. Relying upon their own resources, the proprietors have not hesitated to undergo the risks of the trial; but apart from their isolated and limited efforts, does it not belong to the state to give prosperity and extension to the methods devised by Jacobi, and already carried by men of science in France to so high a degree of perfection?

B—REPORT ON THE PROGRESS OF PISCICULTURE IN RUSSIA.

BY THEODORE SOUDAKÈVICZ.

[Prepared for the Vienna Exposition of 1873, and translated from the French by H. Jacobsen.]

1.—THE DECREASE OF FOOD-FISHES.

The fact that basins which formerly abounded in fish show a decrease does not admit of any doubt, and it is even asserted with good reason that this is not an accidental phenomenon, which might be explained by unfavorable and passing circumstances, but that we have to face a constant and general fact.

In view of the great importance of the fisheries in regard to the question of food and economy, this decrease of fish must necessarily occupy not only scientists and naturalists, but also governments. Observation and experience have shown that the cause of this fact must not be looked for in a weakening of the reproductive powers of fish, which probably are as extraordinary at this day as they were in former times;* it must, therefore, be due to other influences, especially to those which are brought about by man's own doing.

The basis on which a rational system of pisciculture is founded is very simple, and can be limited to the following rules:

1. Preserve the natural conditions of those places where the fish spawn, conditions which favor the spawning-process, and tend to preserve the spawn and protect the first development of the eggs; thus, *e. g.*, everything which diminishes the supply of fresh water; everything which changes the quality of the water or the character of the bottom; everything which hinders the growth of aquatic plants; in fact, everything which at its very source can destroy the wealth of fish of a whole basin.

2. Leave a free passage for the fish to pass to the places which are favorable for spawning, at least as much as is necessary for preserving the species in sufficient quantity; for the best natural conditions for spawning would be useless, if nearly all the fish which went there were caught and destroyed during their journey.

3. Protect the young generation, so that it can arrive at the age of maturity and contribute its share toward the increase of the species.

If these conditions are observed, every large sheet of water, inland seas and large lakes, may become as rich in fish as the quantity of nutritive substance contained therein will permit. Certain hurtful influences such as, epidemics, or the too great development of animals which feed on spawn, can doubtless diminish the number of certain

*Thus, the codfish deposits 9,000,000 eggs at one time; the tench about 350,000; the perch, 300,000; the carp contains 50,000 eggs to every pound of weight; the pike, 40,000; the salmon, 25,000, &c.

species; but this will soon be rectified again, and man alone, with the powerful means at his disposal, has the power to destroy this order for ever and to his own great detriment.

But human influence itself varies considerably according to local conditions. In the oceans and large seas man cannot injure the spawning-places of those fish which deposit their spawn in the sea itself or at a great depth, as for instance, the cod, nor can he prevent the fish from reaching these places. He can neither destroy the spawn nor, as a general rule, catch those young fish which have not yet attained the age of maturity. These young fish escape and spread over the immense extent of the sea.

In rivers, lakes, and other limited sheets of water, the fish are brought within the reach of man's influence under very different conditions; here we find that the basis of a good system of pisciculture mentioned above is wanting either entirely or in part.

This fact is also established in Russia, not only with regard to the lakes, but also to the inland seas, such as the Caspian Sea and the Sea of Azov. The abundance of fish in these seas is truly astonishing, and surpasses everything which is known of the most celebrated fisheries of the ocean, such as the Newfoundland Bank,* the Dogger Bank, or the Westfiord in Norway. But this large number of fish depends to a great extent on man's action. In the Sea of Azov, the principal and almost only source of, what is there called the "white fish," (*Lucioperca sandra*, Cuv., *Leuciscus Heckelii*, Nordm., and *Cyprinus carpio*, L.,) is the delta of the Kauban, which combines all the most favorable conditions for spawning.

Throughout its whole extent enormous fisheries are carried on, the young fish are saved, and all the regulations tending to protect the circulation of fish in the net-work of lagoons, in the branches of the delta, and the bed of the river are carefully observed. If, however, this system of pisciculture at the mouths of the Kauban was not modified, it might have a bad influence, not only on the river-fisheries, but also on those of the Sea of Azov, on account of the transformation of the vast lagoons, where millions of fish spawn, into salty marshes. In the Volga and in the other rivers which fall into the Caspian Sea, the distribution of the water in the delta is not hindered in any way. The fishing of young fish by means of nets with narrow meshes is not in vogue; but, on the contrary, it is not very long since the whole space extending before the mouths of the Volga was encumbered by innumerable lines of fishing-apparatus, and the free circulation of the fish which had entered the river was hindered by the constant use of draw-nets, and by the river being filled with hooks, nets, leaps, and crawls. Consequently an insufficient number of fish was allowed to pass on to the spawning-places. The law of 1865, with its new regulations, has abolished this abuse. In the inland lakes of Russia, which cover a vast area in the northwest,

*The number of fish caught at Newfoundland is scarcely half that of the Caspian Sea.

especially in the shallow lakes, which are well known for their wealth of fish, the third condition of rational pisciculture mentioned above would often have been disregarded, *i. e.*, people would have fished the young fish before the age of maturity if nets with narrow meshes had not been prohibited.

2.—PISCICULTURE.

The decrease of fish in consequence of a bad and destructive system has attracted the attention of the governments, nearly all of whom devote more or less considerable sums to the encouragement and development of the fisheries, in order to diminish the destruction of fish by means of various protective measures. The decrease of the Russian fisheries has led the imperial ministry of domains to make a series of statistical researches with regard to the fisheries, with a view of throwing light on all the causes of this decrease. These researches, commenced in 1859 and finished in 1872, have been made in the Baltic, the Polar Sea, the White Sea, the Caspian Sea, the Black Sea, and the Sea of Azov, as well as in the more important lakes. The result of these investigations has served as a basis for the new legislation, and has led to administrative measures looking toward the protection and development of the fisheries.

In Russia, as well as in other countries, the government has been aided in its efforts by a new science, which in our days has become of the greatest importance as a branch of national industry. The labors of various distinguished scientists, who have devoted themselves to the study of icthyology, have led to interesting discoveries, several of which have proved of the greatest practical use. One of the most important among these last-mentioned discoveries is the artificial impregnation of spawn, which, as experience has shown, enables us to multiply the most valuable species in the most favorable localities, or to renew the wealth of fish which had been exhausted by a destructive system of fishing.

This discovery can be traced back to the middle of the eighteenth century, but its practical application as a branch of industry dates only thirty years back. The artificial raising of fish is in our days encouraged and aided by government, has developed extensively, and has rendered the most valuable services to the public well-being.

Pisciculture, or the art of propagating fish, was known to all civilized nations even in the most remote times. In the beginning, the following method was observed: At the spawning-season, fagots and branches were placed in the rivers and their tributaries, forming hedges, on which the fish deposited their roe as on a natural bottom. After the roe had been impregnated, it was gathered and taken to those places where one wanted to introduce fish or multiply them.

In the fifteenth century other methods of propagating fish were employed. Long wooden boxes were prepared, open at the top, and their straightest sides being composed of osier or reed trellis; at the bottom of

these boxes a layer of fine sand was placed to serve as a receptacle for the roe; on this bottom the impregnated roe was placed, and the whole apparatus put in a place where the roe was exposed to a constant stream of fresh water. The development and hatching of the roe usually took place after three weeks, but a month was required for hatching all the eggs. This invention, which was a progressive step in the art of pisciculture, was improved in 1761 by a new hatching and incubating process. At that time artificial hatching-boxes were introduced, consisting of wooden boxes with perforated sides, in which branches were stuck. At the spawning-season, fish of both sexes were put in these boxes; thereupon the spawners were taken out, and the branches covered with the spawn were placed in boxes in such a manner as to avoid all contact between the eggs.

The discovery of artificial incubation belongs to a Frenchman, Dom Pinchon, (Bulletin of the Imperial Society of Acclimatization, 1854, p. 80,) and the construction of artificial spawning-boxes was invented by a Swede, (Lund, of Linköping;) the third and most important discovery, viz, that of artificial fecundation, was made by Ludwig Jacobi, a land-owner of Lippe-Detmold, (1711–'84,) who has left us an account describing his method very much in detail. This work may serve as a manual of practical pisciculture. The process of fecundation discovered by Jacobi, and known as "moist fecundation," is at the present day in vogue in most of the foreign establishments of pisciculture. In Russia the so-called process of "dry fecundation" is mostly employed. Both will be described below.

Jacobi's discovery was very little known till 1840, when a strong impetus was given to this industry in consequence of experiments in the artificial propagation of fish made in France by the fisherman Joseph Rémy and his friend Géhin. These experiments attracted the attention of the government, which shunned no expense and appropriated large sums for founding the establishment at Hüningen, placed at first under the direction of Berthot and Detzem, and finally confided to the care of the celebrated Coste. Through the influence of this establishment, which soon placed itself on a commercial footing and made it an object to sell fecundated eggs and fry, pisciculture developed very rapidly; and there is at this day scarcely a country where this industry is not known and does not attract the attention of land-owners. In Russia, the number of piscicultural establishments increases every day, in spite of the country's great wealth of fish.

Among these establishments, that of Nikolsky, located in the village of the same name, (province of Novgorod, district of Demyansk,) takes the first place, on account of its extent, its excellent technical arrangement, and, finally, by its method of fecundating eggs.

The establishment of Nikolsky belongs to the government, and is under the department of agriculture and rural industry.

In order to get a clear idea of all the operations of pisciculture, it will be necessary to consider each separately.

3.—SELECTION OF MALE AND FEMALE FISH.

For artificial fecundation it is indispensable to select fish which have attained their full reproductive maturity, and, as much as possible, at the very time when the spawn is ejected. This condition is very important; for fish, when it is at the natural height of its existence, is only with great difficulty kept in a condition favorable to reproduction. In order to follow the progressive maturation of the spawn of the female fish, so as to be able to use it at the proper time, one proceeds in the following manner: Several male and female fish of one species, or of two species if one wants to cross the breeds, are placed in reservoirs large enough to allow the fish to move freely. Every species is placed in a reservoir specially arranged in such a manner as to let each one have the temperature and the kind of water which it prefers. The trout, for instance, the various kinds of salmon, and the sturgeon, which propagate in running cold water, must be preserved in reservoirs fed from sources of fresh water; and if these cannot be had, the water must be changed frequently. Other species, such as the large pike, the carp, the perch, &c., which deposit their spawn in stagnant water, must be placed under similar conditions. In the establishment of Nikolsky the fish are preserved in ponds of running water, and a short time before the fecundation they are transferred to basins likewise supplied with running water, which are in the establishment itself.

When it is impossible to get living reproductive fish, one may use dead ones. Thus, during the first time of its existence, the establishment of Nikolsky had frequently to use, and nearly always with success, dead female fish which came from St. Petersburg. During the transportation, the genital aperture was closed with bandages, and the fish, wrapped up in hemp, were laid on their backs. It has been positively proved that the milt, as long as it is contained in the reproductive organs, preserves its prolific qualities for a very long time, and does not even suffer from cold, but if diluted with water it loses its strength very quickly. According to the testimony of several scientists, (Quatrefages,) every movement of the spermatozoids is stopped in milt which is diluted by water, under the most favorable conditions, in the pike in 8 minutes 50 seconds, with the roach in 3 minutes 10 seconds, in the carp in 3 minutes, and in the perch 2 minutes 40 seconds. As regards the spawn, we have not yet exact data as to how long a time it preserves the faculty of receiving the influence of the spermatozoids according to the temperature and the species.

When the eggs and the milt have attained their full maturity, which can be seen by certain external signs, (the swelling of the belly of the female and the enlargement of the genital opening of the male,) one proceeds to fecundate, which is done in two ways, according to the species of fish.

4.—THE FECUNDATION OF SPAWN.

Those fish which spawn on the sand, for instance, the trout, the lavaret, and the whole family of salmon, produce eggs which are easily separated, and which do not stick to other objects; but those species which deposit their spawn on aquatic plants—the carp, the pike, the perch, &c.—produce glutinous eggs, which adhere closely to the plants. The artificial fecundation of spawn of the first kind is also done in two ways: by the "moist" and by the "dry process." The "moist process," which is the more ancient, is followed in most foreign establishments of pisciculture; the "dry process," invented by the Russian pisciculturist, V. P. Vrasski, has been adopted in nearly all the Russian establishments, and has even been introduced into some foreign ones. The difference between the two methods is apparently very insignificant, but the results obtained by the "dry process" are by far the more advantageous. The "moist process" consists in taking a vessel of sandstone, of porcelain, or of wood, which must be perfectly clean, and constructed in such a manner as to have an opening equal in size to the bottom, or a little larger. The bottom must present an even surface, so that the eggs can be freely spread on it.

Enough water is poured into the vessel to cover the bottom to the height of two or three inches. The temperature of the water depends on the species of fish. The most convenient temperature for trout and salmon is from 39° F. to 50° F. The same temperature is good for those species which spawn in winter. For the pike it must be 41° F. to 50° F.; for the perch and the whole family of sturgeons, from 57° F. to 61° F.; and for those fish which spawn in summer from 68° F. to 77° F. In one word, it is necessary that the temperature of the water used for artificial fecundation is as near as possible like the average temperature in which the species lives that is to be operated upon. A difference of 6° to 8°, more or less, may stop the fecundation completely.

After this, one takes a female fish with the left hand and holds it perpendicularly above the vessel. The eggs generally fall into the vessel by their own weight, but if this is not the case one presses the belly of the fish gently with the forefinger of the right hand from top to bottom. After having gathered the spawn of the female in the vessel the milt is extracted from the body of the male fish in the same manner. When the water assumes a turbid and milky appearance, the spawn is mixed with the milt by means of a feather or the tail of the male fish. After 5 or 10 minutes the fecundation has operated; then the spawn is washed, the water in the vessel renewed several times, and the eggs placed in basins destined for their reception.

In order to fecundate spawn a peculiar apparatus is also used, consisting of a sieve with a metal tissue narrow enough not to let the eggs pass through, nor to allow them to be entangled in the meshes. The sieve is plunged into a vessel filled with water; its sides can be either

of wood or metal; but if metal, they must be the same as the tissue, in order to avoid galvanic currents, which might hurt the spawn. This apparatus is convenient, for it dispenses with the necessity of changing the water containing the milt. After the fecundation, it runs out of itself through the holes of the sieve.

The "dry process" of fecundating spawn, invented by Mr. Vrasski, differs from the preceding by requiring two vessels, one for the spawn, which is put there without water, and the other for the milt, to which water is added to moisten the eggs. This method is extremely advantageous, for in using it scarcely 1 per cent. of the eggs escapes fecundation, while in the "moist method" 10 to 12 per cent. of the spawn may be lost. A little spoonful of milt is sufficient to fecundate 1,000 eggs. What has prevented the spreading of this method in other countries is the very improbable opinion that it is not applicable to fish which spawn in autumn or in winter, or at a low temperature in general. The principal conditions of success in the operations which we have just described are always: full maturity of the eggs and milt, a suitable temperature, and rapid execution.

The following is the method employed for fecundating glutinous eggs: It requires some bunches of aquatic plants, which are carefully washed, (*Ranunculus*, *Glyceria aquatica*, &c.,) a vessel of the shape and size of those used for the preceding operations, and a bucket. The manipulations require three persons. One of them holds the female fish, and extracts the spawn from it as described above, while the other extracts the milt from the male. The third person stirs the water with a bunch of plants, to favor the absorption. The spawn sticks to the plants, which are left for two or three minutes in the water containing the spermatozoids, so as to insure the fecundation of the eggs. Then the bunch of plants is washed with the spawn sticking to it, and put in the incubating-apparatus. As the fecundation of glutinous spawn requires the aid of several persons, and as, besides, the species of fish which have this spawn do not cost very much, it is usually multiplied in artificial incubating-apparatus, which has the advantage of avoiding almost entirely the loss of spawn, which, in the natural course of events, is inevitable. The construction of this apparatus varies very much. The simplest consists of two pieces of wood joined by several transverse pieces trimmed with aquatic plants. This apparatus is put in the water several weeks before the spawning-season; then it is taken out of the water. The plants are also taken out and placed with the eggs that are on them in the incubating-apparatus.

5.—THE INCUBATION OF SPAWN.

After the fecundated spawn has by itself become detached from the fecundating-boxes, it is put in an apparatus with compartments, where the incubation takes place. For this operation we may use a shovel, or we can also simply incline the vase which contains the spawn as near

as possible to the bottom of the box into which it is to go, and pour it directly on this bottom. In this operation, care must be taken that the eggs do not lie on each other in layers. If among the eggs there is a little coagulated milt, it ought to be first washed out.

The apparatus for incubation and the hatching of young fish are very different. Every pisciculturist has his own models made to suit local convenience and his own individual ideas. The apparatus also varies according to the species of fish; the trout, the lavaret, the salmon, for instance, requiring cold running water, the incubating-apparatus must answer these conditions.

The article of this kind which is most used, on account of its answering its purpose best, is that of Coste. It is about 1½ feet long and 1½ broad and deep. The lid is formed of two parts, which open by hinges; these two panels have each a square opening, closed by a net-work of metal; the two straight sides of the box have also doors with openings like those of the lid, likewise furnished with the net-work of metal. Inside the box, at the ends and in the middle, there are cross-pieces of wood, on which other frames are placed, which are the most essential pieces of the apparatus; these frames consist of thin plates of glass in wooden frames; as many as four of these are placed on the same cross-pieces, and the fecundated spawn is put on these glass plates. On the bottom of the box sand is put, in case some eggs should escape through the small spaces between the strips of glass. This arrangement has the advantage, above all others, of being easily cleaned, and not bringing the spawn into immediate contact with the metallic sides, which might make it cold, might tear its delicate skin, and might jeopardize the life of these frail creatures.

For propagating fish on a large scale, the above-described apparatus, and other similar ones, are replaced by special incubating-canals, into which water is led from a spring or a pond. The arrangement of these canals is very simple; the water flows through a series of wooden or stone basins, covered with a net-work, to avoid all obstruction. In these basins the spawn is deposited on glass grates.

To incubate spawn in localities where there is no running water, other apparatus is used, the most common being that of Coste. This consists of a filtering-apparatus, which leads the water, through a pipe with a cock, into one or two basins made of sandstone or delf, on whose bottom gravel is placed; at the end of this basin the current divides into two, and, through small gutters, the water flows into troughs of sandstone, placed one over the other and parallel to each other; every one is provided with a slope or gutter on the side opposite to that where the water flows in. In this manner the water which comes from the delf basin and which flows through this whole system of basins forms an artificial brook. After having flowed through this whole apparatus, this water is collected in a special reservoir destined for the fish which have just been hatched, and from there it flows out.

During the period of incubation, the spawn requires the greatest care. The washing of the eggs immediately after the fecundation is rather difficult on account of their delicate outer skin, and this is precisely the time when they must be cleaned from all impurities ; for the development of parasites is fatal to them at this time. The cleaning of the spawn is done by means of the down of a quill or with a soft brush ; the spoiled eggs, which can easily be recognized by their pale-yellow color, are picked out with pincers similar to those used in anatomy, but differing in this respect that, instead of being denticulated, they terminate in a cavity which seizes the spoiled egg without endangering the others. If, on account of too strong a current of water, the spawn gets piled up in one place, which ought to be avoided, we must immediately diminish the current and spread the spawn evenly over the whole bottom; using for this small glass tubes, which are made in the following manner: take a tolerably large glass tube, blow a globe at one of its ends, and draw out the other end to a fine point; the large opening is closed by a stopper pierced lengthwise, through which a thin glass tube is passed. In using the tube, stop with the finger the thin end, and direct the the tube which passes through the stopper on the spawn, which, as soon as the finger is raised, passes rapidly at the same time with the water into the globe of the tube.

This instrument can be used not only for transporting spawn, but also for taking hold conveniently of small newly-hatched fishes.

6.—DEVELOPMENT OF THE EMBRYO AND THE HATCHING OF FISH.

The egg of a fish is composed of an inner bladder, which, as long as the egg is not put in the water, is in intimate contact with an outer covering. The inner bladder and its covering are joined by a thin channel, which, on the outside, opens by an orifice called micropyle, through which the spermatozoids enter the eggs. This opening was first discovered on the egg of a small bream (*Abramis blicca*, C.) by a Russian scientist, Mr. Baer, of the Imperial Academy of Sciences of St. Petersburg, and was next observed on the trout, the salmon, and the pike, &c. As soon as the egg has been brought in contact with milt diluted in water, or simply with pure water, the outer covering swells, through endosmosis, and separates from the coating of the inner utricle. During this absorption of water through the outer skins of the egg, it is absolutely necessary that a spermatozoid with fecundating liquid should, through the micropyle, pass inside the bladder. If this is not the case, no fecundation takes place. During the separation of the outer skin of the bladder, the channel intended to introduce the spermatozoid into the egg breaks, and communication between the bladder and the outside is interrupted; so that, if the spermatozoid has not had time enough to penetrate into the bladder, it cannot possibly get into it afterward, and the egg remains barren. These observations prove that it is very important that the spermatozoids of the milt, diluted in water, should be

still in motion when the process of fecundation goes on, and should be able to take their course toward the opening of the channel and penetrate into the interior of the egg. We have seen that the movement of the spermatozoids cease very soon after diluting the milt with water; it is, therefore, highly important, for a successful fecundation, to dilute the milt and impregnate the spawn with the mixture as rapidly as possible. The inner bladder of the egg contains albumen and yolk; this latter is at first spread throughout the whole bladder, but after fecundation it all collects on one point and forms a separate yolk, (vitellus.) Then the yolk divides into two hemispheres, which again are divided; then the vitellus occupies two-thirds of the bladder. Finally it is possible to distinguish the head, the vertebral column, and the tail of the embryo; and about a month before being hatched the eyes can be distinguished in the shape of two black spots. In the lavaret they can already be seen in January.

The skin of the egg is soft before being fecundated, but after fecundation it becomes thicker and so hard that it is almost impossible to crush the egg between the fingers. Toward the end of the development of the egg, the skin secretes a substance destined for forming the hard portions of the embryo, and then it becomes transparent, fine, like the web of a spider, and so delicate, that at the least outside pressure it tears on all sides.

After the fish has come out, it carries with it the umbilical bag containing a supply of nutritive substance, which is absorbed by means of blood-vessels spreading all through the bag. After all has been absorbed, the young being has the perfect form of a fish, and is called fry, ("alevin;") it now requires outside food.

The hatching of fish is not done all at once, but gradually, under the influence of certain external causes, such as the temperature of the water, the quantity of oxygen contained in it, &c. It is necessary to watch the temperature and purity of the water very carefully. Dust floating in the air over the water, and various impurities which fall in the water and mix at the bottom of the basins with innumerable microscopic pieces of vegetable fiber, form tufts, in which, if the temperature of the water is higher than 50° Fahr., myriads of infusoria develop. These tufts get into the mouths of the young fish, and, being ejected together with the water, obstruct the gills and produce suffocation.

After having absorbed the umbilical bag, the fish seeks other food. The possibility of satisfying this want during the first time has a decided influence on the further development. The young fish shows by its first movements an innate tendency to seize food, just as mammalia immediately after their birth instinctively seek the breast which is to give them food. As regards the most suitable food for young fish, the trout and the salmon family chiefly feed on animate matter, *e. g.*, on the spawn or the young of the *Cyprinus alburnus*, Cuv.; on the *Cyprinus leuciscus*, Cuv., (or *Aspius alburnus*, Agass.;) or on fish of the species

Coregonus, Cuv. The young lavarets first feed on insects; but, arrived at a certain age, they also eat the spawn and young of the roach and the ablet. Young trout and young salmon require running water where insects cannot live, while the young of the lavaret requires more stagnant water, because the insects which form his food can there live and multiply. The spawn of the ablet and other small fish which form the food of the trout, the salmon, and the lavaret is obtained in every establishment of pisciculture by means of artificial spawning. As the young fish during the first time of their existence, if they were placed in ponds and reservoirs to increase, would every minute meet with innumerable and unavoidable dangers, (fish, insects, &c.,) and would perish uselessly, one ought, before transferring the young fish to natural reservoirs, to raise them in fish-ponds, which are true nurseries of fish. According to the extent of the pisciculturist's business, these fish-ponds may be merely boxes or ponds, or, in short, any reservoir where the fish can be placed under conditions that are favorable to its development, and where it can be protected against its various enemies while it is still too feeble to defend itself.

7.—TRANSPORTATION OF SPAWN.

The most common way of transporting spawn longer or shorter distances is the following: A wooden pail is used, the bottom and sides of which are covered with a damp cloth, which separates the layers of eggs; this cloth is always kept damp, and in its stead moss or certain aquatic plants may be used, between which the spawn is spread. In doing this, care should be taken that the eggs do not press against each other, and that the pressure of the upper layers does not injure the lower ones. The establishment of Nikolsky sends fecundated spawn in this manner through the whole of Russia. The glutinous spawn is transported with the plants to which it adheres in glass bottles, filled to three-fourths of their capacity with water, or in baskets and boxes wrapped up in damp cloths. The vessels in which fecundated spawn is transported, especially long distances, must always be wrapped in substances which are as little as possible conductors of heat; moss, felt, etc. For the different kinds of salmon the temperature must be 32° to 50° Fahr., while for other fish it must be higher.

Whatever means of transportation be employed, spawn must not be shipped immediately after fecundation, as experience has shown that the best time for this is when the embryo has reached that stage of its development when two black dots can be observed in the place of the eyes.

The transportation of fish depends on its age; the younger it is the easier it can be shipped. Young fish scarcely hatched are sent in glass vessels, the water on which must be changed every two or three hours. This frequent change of water may, however, be avoided by passing a

current of fresh air through it, which is done by means of a tube dipped into the water of the vessel.

Spring and autumn are the seasons most favorable for transporting fish. In the summer they are sent by night, being careful to keep the water constantly in motion, even when a halt is made. During long journeys the water in the vessels is renewed from time to time, and air is introduced by means of bellows and a tin tube.

8.—PISCICULTURAL ESTABLISHMENT AT NIKOLSKY.

After having spoken of the technical part of pisciculture, we will give a detailed description of the arrangement and work of one of the largest establishments of this kind not only in Russia but in Europe. The work done at the establishment of Nikolsky will give us a great deal of information and furnish many instructive examples. This establishment is located almost on the boundary-line of the districts of Démyansk and of Valdaï, (province of Novogorod,) on the high-road, 77 versts (about 48 miles) from the Valdaï station on the Nicholas Railroad. The highest elevation of the Alaoune Mountains is in the districts of Valdaï and Démyansk, and these districts are, therefore, crossed in all directions by high hills. The valleys formed by these hills inclose a large number of lakes, mostly fed by small and rapidly-flowing streams. The water of the lakes is pure and cold. This locality, as will be seen, combines many conditions favorable to pisciculture, especially for the breeding of valuable species, such as the trout. M. Vrasski, a rich land-owner of this province, has made use of these favorable circumstances to found his establishment. After having examined the work done in France by Rémy and Gehin, and after having studied the theoretical part of pisciculture, Mr. Vrasski, in the spring of 1854, made his first experiments on the spawn of eelpout and "jaculus," and finally on that of the trout. The food of the hatched fish presented the greatest difficulties. Meat chopped fine, recommended by some foreign pisciculturists, was unsuitable, and inconvenient in various ways. The food of young trout during their first stage consists of aquatic insects, and, from an inborn instinct, they did not seize the pieces of meat except during their fall to the bottom, but never touched them when motionless. The meat consequently began to decompose, changed the character of the water, and the fish died. Mr. Vrasski then thought of feeding the young trout with the insects which swarm in stagnant water, and obtained favorable results. The trout produced by him in 1855 measured, two years later, 22 centimeters, and in some the milt was matured. After a long series of experiments, Mr. Vrasski achieved the most brilliant results in fecundating spawn, and his experiments led him to the discovery of a new method.

In order to fecundate eggs, it is necessary, as we have said above, that the spermatozoids contained in the fecundating-liquid of the male fish should penetrate into the eggs laid by the female. For this purpose it

was necessary, according to the manual which Mr. Vrasski followed, to press the spawn from the females into a vessel filled with water, to place the milt of the males in another vessel, and, after having diluted the fecundating-liquid, pour it into the vessel containing the eggs. Mr. Vrassky had meanwhile observed that fecundation was less successful if there was any long interval between the time of extracting the spawn from the female and the time of its coming in contact with the milt. If this interval exceeded ten minutes, fecundation failed almost entirely. By numerous microscopic observations made with Dr. Knoch, a learned embryologist, Mr. Vrasski convinced himself that, in coming in contact with water, the spawn absorbs this liquid, and that the process of absorption takes no longer than half an hour; but that spawn placed in a vessel in a dry state remains a long time without changing, and without losing its property of absorbing water and of receiving spermatozoids. The spermatozoids of the milt, when brought in contact with water, make violent and rapid movements, which, however, last only one and a half or two minutes, while milt kept dry in a vessel or on a glass plate preserves its qualities for several hours, during which time the spermatozoids show under the microscope the same rapid movements which they make in water the moment they leave the body of the fish. In making experiments with the river-perch and the *Acerina vulgaris*, C., on milt that had not yet reached its mature state, he found that some drops of milt kept in a perfectly dry and well-closed cylinder had not lost their original qualities, even after six days in the ordinary temperature of a room. By combining these data with the circumstance that spawn and milt when taken from the bodies of fish do not come out all at once, but run out gradually and slowly, Mr. Vrassky arrived at the conclusion that, by putting the spawn and the milt immediately in water, the larger portion of the eggs have time enough to get completely soaked, and that the ma'ority of the spermatozoids lose their movements before the pisciculturist has time to mix the prolific water with the spawn. Then Mr. Vrasski commenced to put spawn and milt in vessels without water, and to pour the fecundating-liquid over the eggs immediately after having diluted the milt. The results were entirely satisfactory, for not a single egg remained barren.

After having achieved such a brilliant success in fecundating spawn, Mr. Vrasski associated himself with two others, with the view of founding an establishment on a large scale. For this purpose he used the Pestooka, a river which joins Lake Pestow ($1\frac{7}{8}$ miles long) and Lake Vélio, (about $4\frac{3}{4}$ miles long;) with the water of this river he fed several basins and fish-ponds, where the water could be made to rise or fall by means of water-gates placed farther up the river at the place where it leaves Lake Pestow.

The building, built of wood, on stone foundations, is 12 sagenes (84 feet) long, and 6 sagenes (42 feet) broad.

The water of a pond is conducted into the establishment by means of

a subterranean pipe, and flows into a tub called a "leveller;" this is made of two joists, is 7 feet high, and 4 feet 8 inches long and broad. From this reservoir water is distributed through the whole building. In the middle of the building there is a large basin fed with running water, which serves as a fish-pond for the male propagators and the females. It is made of planks, 49 feet long and 9 feet 4 inches broad; it is divided into several compartments, into which propagating fish of every kind are placed separately during the period of fecundation.

Parallel to this fish-pond there are, on every side, eight smaller basins, made of flagstones and supported by brick arches; each of these basins is 23 feet 4 inches long, 3 feet 6 inches broad, and 10½ inches deep. A pipe coming out from the bottom of each of these basins feeds them with filtered water, which is kept ⅞ of an inch high; after having flowed through these basins, it flows out through a common outlet-pipe. The water of these basins is so pure that it is possible to discern the smallest straw at the bottom. In these basins not only the fecundated spawn is kept placed in small square troughs, but also the young fishes, which, till the time of their being placed in the lakes and ponds, are there fed with larvæ of insects and with young ablets, which are expressly raised in the establishment for this purpose. On every side of the "leveller" there are two square boxes for filtering water through layers of sand and flint stones; from these boxes the water passes into a third filter, and flows into the boxes where the fecundated eggs are washed.

For raising fish the establishment has, besides the lakes and the river, five ponds with running water, placed one higher than the other. There the young fish which have reached a certain degree of development are transferred from the basins in the building; there, also, the propagating fish are kept. The development of embryo is entirely successful; and this result is due as much to the "dry process" of fecundation as to the arrangement of the boxes with compartments, and finally to the low temperature of the water (35° F.) in which the eggs are developed. In other countries the eggs of trout are kept in a temperature several degrees higher than that of the water in the Nikolsky establishment, which induces the development of plants and minute animals, which are injurious to the eggs. At Nikolsky the sand (which has been previously washed in boiling water to destroy all animal and vegetable germs) and the eggs are five weeks after fecundation as clean as at the time they were deposited, while in foreign establishments they are obliged almost constantly to clean them from the spawn of parasitical plants and animals. At Nikolsky hatching goes on slower than in foreign establishments, which is but the natural result of the low temperature of the water; but the slow development of the spawn has this advantage, that the embryo grows more regularly, and that the young come forth precisely at the time when insect-larvæ abound most, so that they are sure of their food. The trout and the salmon generally spawn in November, and thus in foreign establish-

ments, at the comparatively high temperature of 43° Fahr., the young fish develop and require animal food as early as February, a season of the year at which it is impossible to get insect-larvæ; it is therefore necessary to feed the fish on chopped meat, which, besides being expensive, changes the nature of the water and occasions a loss of fish. In our establishment, however, the development progresses more slowly, so that the young fish, which at first requires no food (the umbilical bag, as we have said before, is during this first stage of development absorbed by it,) is hatched in April, and becomes a young fish in the middle of May, when a large variety and abundance of suitable food can be found in every sheet of water. This food consists of living aquatic animals and insect-larvæ, which are gathered with muslin nets. At the end of May the young of the ablet, (*Cyprinus alburnus*, L.,) taken immediately after being hatched, are added to this food.

During the period of raising the young fish in the establishment, special care must be taken to prevent the drowsiness or sleep of the young fish. In a low temperature everything works well, but as soon as the temperature of the water is elevated, the young fish show a certain restlessness in their movements; they gradually seek that part of the apparatus which receives the water fresh from the feed-pipe, and there they gather in compact masses; their respiration is accelerated, the mouth remains open, and the gills move with an effort; then the tail and head grow pale, and finally the fish dies. This sickness increases in proportion to the heat of the water; and the more sudden the transition from cold to hot the quicker does the young fish die. This circumstance is explained in the following manner: Water, like all liquids, has the property of absorbing gases. The quantity thus absorbed increases when the temperature gets lower, and is less when the water is hotter. This property of water is especially important with regard to oxygen, which is one of the elements of the air, and which can continually dissolve in water. The absorption of oxygen by water has an immense influence on the life of fish. The young fish through its gills is constantly inhaling oxygen contained in the water, which passes into its mouth and decomposes its blood. At the same time it ejects with the water carbonic acid, which is a superabundant element in its organization. If the water contains less oxygen than is required to oxidize the blood, the gills change their lamellæ, and their fringes agglutinate, decompose, are covered with parasites, and the want of oxygen necessarily brings about the death of the fish. The necessity of oxygen forces the young fish toward the place where the water has not yet become saturated with carbonic acid, viz, toward the opening through which the compartment is fed with water. Each fish seeks to drive away the other to get sooner to the fresh water; the feebler ones have to give way, become still feebler, and perish on account of insufficient respiration. To avoid this suffocation of the young fish, the following methods are employed at Nikolsky:

1. Through the box, with compartments at a certain distance from each other, and at a convenient height above the boxes, zinc pipes are placed, pierced by straight openings, joined to each other, and at their ends to other larger pipes. Some of the water coming from the filters in this way flows out into the box, through the openings of the pipes, in the shape of a fine rain. All these small drops of water pass through the air during their fall and become saturated with oxygen; in striking the surface of the water, they refresh it with diminutive drops, which, rising and falling, increase the absorption of oxygen.

2. To renew in the water the oxygen destroyed by the respiration of the fish, air is also blown into it by means of bellows. This method is particularly useful, because the air, entering the water from above and below, only passes through it slowly, being retarded in its progress by the pressure of the upper layers. Moreover, the contact between the water and the air is more complete, and is brought about on comparatively larger surfaces, which, of course, causes a greater absorption of oxygen. In following this method, care should be taken to blow air into the water for a tolerably long time; and if it is impossible to do it continually, it should at least be done in such a manner as to let this aerating process go on, not only in one place of the box, but throughout its whole extent.

3. As, independent of the respiration of the young fish, the decrease of oxygen is brought about by heightening the temperature, this inconvenience is remedied by putting ice in the filters or in the boxes, the ice being put in special receptacles, so that it cannot communicate its impurities to the water.

Jointly with this method, the following is also employed: as soon as the temperature of the water commences to rise, the embryo, even if it should not yet have reached the state of young fish, is transferred to the ponds, where, as much as possible, it is placed in the bed of the Pestooka River, which flows through all these ponds.

The extent of the establishment enables it to fecundate annually 5,000,000 lavaret * eggs, 2,000,000 trout eggs, and more than 1,000,000 salmon eggs. The basins and nurseries are large enough to raise and feed every year more than 600,000 fish. Besides this, the establishment can prepare for the trade about 1,000,000 eggs which have reached that stage of their development when the eyes of the embryo can be discerned through the skin.

The establishment of Nikolsky, for the foundation of which, independent of the personal funds of the founder, the government has granted a subsidy of 30,000 rubles, ($21,000 gold,) was, till the year 1868, under the direction of a society of pisciculturists, but since that year it has become the property of the national treasury, and is at present under the department of agriculture and rural industry. As long as it was in the hands of private individuals, its aim was almost

* White-fish, (*Coregonus*.)

exclusively a commercial one; *i. e.*, the sale of fish raised in the establishment, particularly to the two capitals, Moscow and St. Petersburg. But after it became the property of the government, the establishment has in pisciculture assumed the same place as a model-farm in agriculture, or an acclimatizing-garden in horticulture.

Three methods are known of propagating new species of fish:

1. The transportation of grown male and female fish to a certain given locality. By this means salmon and salmon-trout have, in 1852, been introduced in Lake Peipus; but by this means but a very limited number of fish can be propagated in a river or in a lake, as, on account of the vast extent of these natural reservoirs, there is very little chance of the two sexes meeting at the proper season and in a favorable place, so that this method is far from insuring the multiplying of the species.

2. The transportation of fecundated spawn by natural means from one reservoir to another. This method is often followed, and in many cases it leads to good results; but it could not be applied under all circumstances, for many fish spawn at a great depth, or in inaccessible places.

3. The transportation of spawn that has been fecundated artificially. This method answers the purpose best.

The establishment of Nikolsky is in a locality which communicates with the basins of the Volga and the Ladoga. It is only one verst (five-eighths of a mile) from Lake Vélio, which, through small rivers and a lake, communicates with Lake Ilmen. These rivers are the Yavon, the Polla, and Lake Seligher, which, through the Selijarooka River, has a communication of about sixty miles in length with the Volga. Thus the establishment combines the climatic conditions of the basins of the Volga and the Ladoga—conditions which are very favorable to the acclimatization of fish from one basin to the other. The common lavaret, for instance, does not exist in the basin of the Volga, while it abounds in that of the Ladoga; the latter, on the contrary, has no sturgeon, while these are very common in the Volga. The establishment has, therefore, made it its object to spread in the basins of Russia those species of fish which are wanting, but which, as far as the quality of the water and the climate are concerned, might be introduced there, and which, by their price, might offer great advantages to fishing-industry. With this view, the introduction of lavarets into the basin of the Volga was undertaken. Numerous species of this fish, as we have said above, are found in the basin of the Ladoga, while in that of the Volga only a single one is found, the large and excellent species of white lavaret, called in Russian "Bélorybitsa." As the place of transportation, Lake Seligher has been selected, where every year several thousand lavarets one and a half vershock to three vershocks (two and a half to five inches) in length are let loose.

The success of this attempt can no longer be doubted, considering that the fish loosened in the Volga constitute the second generation of

lavarets bred and raised in the establishment and completely acclimatized in a locality midways between the basin of the Ladoga (the home of these species) and that of the Volga; so that these fish in being transported to the latter do not undergo any material change of natural influences.

Among the species of the sturgeon kind it is principally the sterlet (*Acipenser ruthenus*, L.) whose artificial breeding has long since attracted the attention of Russian and foreign pisciculturists. The attempts at artificial fecundation of this valuable species made in Russia in 1869 led to excellent results, and during the course of the year 1870 the ministry of domains was able, at the request of the British government, to send several thousand sterlet-eggs to Scotland; these eggs arrived safely at their destination, packed in tinned copper vessels, and were placed in the rivers of that country.

Since 1870 the piscicultural establishment of Nikolsky has made experiments in multiplying sterlets in lakes and ponds. The former experiments in multiplying these fish by letting grown fish loose had always failed. The fish lived, grew, but they did not increase; which circumstance induced the erroneous opinion that it is absolutely impossible to multiply sterlets in ponds and lakes. The cause of this failure not having as yet been studied exactly, the belief may be allowed that this opinion does not rest on a solid basis. Of all piscicultural establishments, that of Nikolsky, being in Russia, the home of the sterlet, has the exclusive opportunity of studying and of solving definitely the problem of multiplying this fish in lakes and ponds; the experiments which have been commenced for this purpose are still going on and will be continued till definite results have been obtained.

In 1871 the establishment of Nikolsky commenced to sell fecundated spawn and hatched fish with the view of giving private individuals an opportunity of introducing valuable species at a moderate price, into their own waters. The spawn is delivered by the establishment in that stage of development when the eyes can be discerned through the skin. From the time that the establishment has advertised the sale of spawn and of hatched fish, it has received orders from different parts of the empire amounting to several tens of thousands of eggs, as well as of hatched fish of the trout, the salmon, and the lavaret, delivered at a fixed price; besides this, about 2,000 eggs are sent *gratis* every day to the Academy of Forestry and Agriculture at Pétrovsky, near Moscow. Spawn is sent to the most remote provinces of the empire, for instance, to the province of Stavropol, without undergoing the slightest change. It is remarkable that the spawn sent to the Academy of Pétrovsky when the cold was severe, froze during the journey in spite of its being covered, and thawed in cold water on its arrival at Moscow, has not suffered in the least, and that of 2,000 eggs only ten were not hatched. Spawn is transported partly as merchandise by express train, and partly, under the authority of the minister of the interior in the mail-cars.

The fish are sold from the age of six weeks to two years; the prices fixed for spawn and fish are the following:

	Gold.
1,000 trout or lavaret* eggs, fecundated, and having reached the stage where the eyes can be discerned	$2 10
100 young trout, six weeks old and able to seek their own food	2 10
100 trout or lavaret, three months old	3 50
100 trout or lavaret, six months old	5 60
100 trout or lavaret, one year old	10 50
100 trout, a year and a half old	17 50
100 lavaret, a year and a half old	14 00
100 trout, two years old	24 50
100 lavaret, two years old	17 50
100 trout, two years and a half old	31 50
100 trout, three years old	38 50

The sale takes place at the following dates: Eggs, from the 1st to the 13th of January to 15th and 27th of March; hatched fish, from 1st to 13th March to 1st and 19th of June; trout and lavaret, one month old, in September and October.

9.—PISCICULTURAL ESTABLISHMENT AT SUWALKI.

We think it our duty to mention, after the piscicultural establishment of Nikolsky, another establishment, founded by the government in the province of Suwalki, with the view of increasing the revenue from local fisheries.

This establishment is located in the water system of Lake Wiczera, on the Ganeza River, which, near the town of Suwalki, flows through Lake Wiczera and falls into the Augustovo Canal. It commenced operations in 1860, devoting itself chiefly to the breeding of trout, salmon, and the two very rare species of lavaret found in these lakes; the "sèja," (*Coregonus marœna*,) and the "seliava," (*Coregonus albula*,) species which are not so rare in the countries bordering this province on the west.

The fish raised in the establishment either from spawn artificially fecundated received from other parts, or from spawn fecundated at the establishment, have been placed in the lake. The species to which they belonged have in this manner been introduced in sixteen lakes in the province of Suwalki belonging to the government. The labors of the establishment have exercised a favorable influence on the revenue derived from the fisheries on Lake Wiczera, so that the revenue from fisheries, which in 1860 brought 120 rubles ($84) per annum, has risen to 700 rubles ($490) in 1869, while the amount of annual revenue from the Lake of Augustovsky has risen from 1,600 rubles to 3,300 rubles, ($1,120 to $2,310.)

The lavaret has been propagated to such an extent that at present this fish is sold smoked on the Warsaw markets, which never was the

* White-fish, (*Coregonus.*)

case in former times. This fish, entirely unknown to the trade, was formerly only found in very insignificant numbers in Lake Wygri.

Among the private establishments we ought not to pass in silence that of Senator Zeumern located about 22 miles from St. Petersburg, which chiefly raises trout.

10.—PISCICULTURE IN FINLAND.

In Finland, pisciculture has assumed vast dimensions; there are at present in that country more than ten large establishments, which propagate valuable species of fish, such as the trout, the salmon, and the lavaret.

The man who has done most for pisciculture in Finland is the famous pisciculturist Holmberg, who, in 1862, became inspector of pisciculture in that country. He has personally contributed toward the foundation of the following establishments: at Stokfors (province of Wyborg) on the coast of the Gulf of Finland; on the branch of the Kioumène River called Souttè; in the town of Tammerfors, where the establishment is fed from the falls of the same name; and at Aborfors on a branch of the Kioumène River. This last-mentioned establishment propagates the salmon of the sea.

Through the active and enlightened assistance of Mr. Holmberg, the establishments of Swarta (Province of Newland) have been founded on the river of the same name. There they principally propagate the lavaret, the salmon, the trout, (*Salmo fario, L.*,) and the carp. It has been observed at this establishment that a salmon which measured 14½ inches and weighed nearly 1½ pounds in August, 1863, had in the month of October attained the weight of 1¾ pounds and the length of 17 inches. It had, therefore, in two months grown in length 2½ inches, and in weight more than ¼ pound. The carp intended for propagating have been brought from Lubeck in 1861. We may also mention the piscicultural establishment of Kroneburg, on Lake Ladoga. Those of Kioumène, located at several points on the river of the same name, near the Gulf of Finland, that of Keksholm, on the Island of Sikkolauter, between the sources of Wokcha and the hills of Keksholm, &c. The fecundation of spawn in these Finland establishments has at first been carried on according to the "moist method" introduced there from Norway; but since 1862 the "dry method," invented by Mr. Vrasski, has been followed with great success.

Regarding the raising of young fish, we must remark, that in the larger number of piscicultural establishments in Finland the young fish, remains only for a very short time in the building, and as soon as it has absorbed the umbilical bag it is let loose in the rivers.

As food, the young of the *Aspius alburnus*, Agass., are used, raised specially for this purpose; the larvæ and cocoon of the viviparous fly, (*Sarcophaga carnaria* Cuv. *Musca carnaria*, L.) and finally flesh of fish or meat chopped fine.

The salmon are particularly fond of quite young ablets; thus in the

establishment of Swarta it has been observed that young salmon would in a few moments devour seven or eight little ablets.

Independent of the establishments which are employed in the propagation of "winter fish," there are in Finland many other establishments which raise the several kinds of "summer fish," the perch, the bream, &c. These establishments are found throughout the whole interior of the country, and their number increases every day, for they require neither any very great expense for starting, nor much care in working them.

C—REPORT ON THE STATE OF PISCICULTURE IN FRANCE AND THE NEIGHBORING COUNTRIES.

BY M. BOUCHON-BRANDELY, *Assistant Secretary of the College of France.*

[Report to the minister of public works in 1873, translated from the French by H. Jacobson.]

1.—INTRODUCTORY REMARKS.

Pisciculture, which, in the College of France, has developed so rapidly under the direction of our celebrated physiologist, M. Coste, and of M. S. Chantran, is a science which ought to have a place in the system of instruction.

The mission which you have confided to me has enabled me to trace the outlines of an economical and practical treatise, which I shall soon have the honor to present to your excellency in complete shape.

We know from the reports of Mr. Ashworth how much Great Britain has profited by the national enterprise of M. Coste, since as early as 1860 the salmon-fisheries of Scotland and Ireland alone amounted to more than £800,000. Germany, Belgium, and Holland have likewise profited from our establishment at Hüningen, which has been organized under the direction of M. Coste, thus putting to practical use a discovery in physiology.

The countries which I have visited, Switzerland, Austria, Italy, all equally show signs of remarkable progress, which is due to the lead taken by France.

It would be very much out of place in our day to trace to the ancient inhabitants of China and India discoveries to which they were perfect strangers. We must not confound pisciculture, properly so called, with the art of fishing, which at all times and in all countries of the globe has been held in great honor; and Rémy has certainly not got his idea of fecundating spawn artificially from the annals of the celestial empire. Nor had the College of France to look for advice to India or China in making its first scientific attempts, which have been crowned with such signal success. Not much time was consumed in developing this first great idea, and Hüningen was established. The

favorable results which had been obtained are at the present day in danger of being lost.

The idea has been broached of replacing Hüningen by an establishment in France organized on the same plan, but your excellency will see from the concluding part of my report that, in order to meet satisfactorily the demands of pisciculture, you ought to increase the number of establishments by diminishing the importance of each one.

Professor Joly, of Toulouse, has, in 1866, published a report on river pisciculture in France, which gave rise to the brightest hopes. The disasters which have fallen on our unfortunate country have again made all this questionable; but if we have lost Hüningen, the laboratory of the College of France still exists and continues the work commenced at another period under such brilliant auspices. From that institution comes the impetus, and I had new proof of this during the tour which I have just made through Switzerland, Austria, and Italy.

2.—Switzerland.

Switzerland, more than many other countries, has profited from the new science of pisciculture, and the progress made in that country deserves to be widely known. The federal government, the cantonal governments, and private individuals saw that this science contained a new and fruitful source of wealth for a country whose waters are of such excellent quality and are so well distributed. Pisciculture has made Switzerland its adopted country. Establishments have been founded by cantons and by private individuals. To these last mentioned the State granted great privileges, and the fishing-laws protect them, and at the same time favor their experiments.

In Switzerland, as in France, the number of fish in rivers and lakes decreased rapidly, and in spite of their great wealth of fish it was high time to remedy this matter. Artificial pisciculture has supplied the remedy, and at present the fish increase as fast as they are destroyed.

Before reviewing the establishments which I have visited, I must mention a fact selected from a large number: the inhabitants of the village of Vallorbe, near Jougne, about twenty years ago lived from the fisheries in the river Orbe. By exhausting this river, which was especially rich in the salmon kind, without ever replenishing it, the fishers and their families were reduced to absolute want. The observations of Rémy, confirmed by experiments made at the College of France, reached the ears of the schoolmaster of the village; he first studied pisciculture theoretically, and finally attempted some experiments, which were crowned with success. The inhabitants of the village anxiously but somewhat incredulously followed the different phases of the artificial hatching of fish-eggs, which went on under the most favorable conditions. The village became interested in these experiments, and several hundred francs were annually appropriated for aiding the schoolmaster in his enterprise. At the present day the river swarms with fish, and

according to the official report there are eighty families which live entirely off the fisheries.

The first establishment which we visited in Switzerland is that of Dr. Vouga, a learned and conscientious man. Every pisciculturist knows Dr. Vouga by reputation, and at the last scientific congress held at Lausanne a conference regarding his work was held, and was greatly appreciated by scientists. His method of artificial fecundation consists in placing the eggs in a vessel without water and then pouring in the milt. Of 6,000 eggs which he thus fecundated last year not one proved a failure. The establishment of Dr. Vouga has not yet been entirely organized, but it has already rendered excellent service, and the river Reuss, which is farmed by him, is now, through his exertions, completely stocked with fish.

Mr. Hasler, of Interlachen, is an intelligent and practical man, who by himself has learned all the secrets of pisciculture; he makes many experiments on the nature of the water and its influence on the development of fish. His establishment is fed from a very pure spring and from the Lutschine, a stream formed by the glaciers of the Jungfrau. Mr. Hasler has carried on pisciculture for four years only, and he possesses the most remarkable specimens of fish, which he has bred and raised artificially. The question of food constantly occupies his attention, and we believe that the system he has adopted, and which consists in putting the young fish in water which was but seldom renewed, allowing the infusoriæ to develop, will prove very satisfactory in the end.

The cantonal establishment at Zurich, located at Meilen, has been in operation for sixteen years; it is destined to replenish the Lake of Zurich from the waters which feed it, and to improve the species found in that part of Switzerland. The government annually appropriates the sum of 3,000 francs for this establishment.

Every year, in the month of October, the government orders the fishers to gather, at the sources of the Rhine, salmon destined for reproduction. These salmon are placed five in a cask filled with water and capable of holding from 400 to 500 liters, (87½ to 109 gallons.) They are sent to Zurich by railroad, and from there to Meilen by steamer. During the journey the water is renewed three times. At Meilen they are placed in water to await the time of maturity.

In the reservoirs of the establishment very fine lake-trout are kept, with which a cross-breed is produced. The object of this crossing is to produce a variety of the salmon kind, having the shape and quality of the salmon, and preserving at the same time the habits of the trout, *i. e.*, it is desired to produce a stationary salmon, staying in the waters of the lake, without feeling the necessity of going into the sea. It is believed that this result has been obtained, and it is even thought that this cross-breed is capable of reproduction. The person who is at the head of this establishment has assured us that this is the case, and the experience of Mr. Samuel Chantran, of the College of France, has proved

it. The specimens shown to us were, without a single exception, very fine, and even if this were the only result obtained, it would be a great step toward improving the species.

A million of young fish are every year thrown into the lake of Zurich, which, without this precaution, would not contain a single trout on account of the rapid increase of fish of prey, especially of pike.

The establishment of Mr. Massart, of Berne, is one of the most complete and best organized which I have seen, and shows the great experience of its proprietor in pisciculture. It is located on the banks of the river Aar, seven or eight kilometers (4½ to 5 miles) from Berne. The water which feeds the basins is of two kinds—spring water and river water; during summer the latter is used, because it is more abundant and carries with it more alimentary matter than spring water; it is besides just as fresh at this time of the year on account of the snow melting in the mountains, which are very near. Spring water is used during winter and for hatching. The basins of the establishment are small but deep; the largest only measures 80 square meters and has a depth of perhaps 2 meters; they are dug into the ground.

Mr. Massart, like all pisciculturists who are obliged to experiment in order to learn, has, in the beginning, met with many failures; but by perseverance he has succeeded in averting the misfortunes which seemed especially to strike the young generations. It is well known that the most critical moment in breeding fish is that which follows immediately after the absorption of the umbilical bag. During this period, which lasts at least four to five months, the young fish are frequently attacked by what is commonly called malady of the gills, and at this moment the choice of food is a matter of the greatest importance.

Mr. Massart places his young salmon, two weeks before the absorption takes place, into a large basin, which is not very deep, and but sparingly fed with water, and which remains almost entirely dry for seven or eight months of the year. During this time the infusoriæ have time to develop, and when the young fish are placed in the basin they there find a food which is suitable for their age.

Mr. Massart actually raises 20,000 trout every year, and besides furnishes the Prussian administration at Hüningen with millions of eggs, which are from there sent to different parts of Europe.

Large numbers of white-fish live with the salmon, and serve them as food. Mr. Massart adds to this boiled corn made into a paste. It will scarcely be necessary to say that pike or perch, as soon as they show themselves in the waters of the establishment, are immediately killed.

This piscicultural establishment is destined to a great development, and will render great service to the city of Berne. The government has given Mr. Massart the right of fishing at every season of the year, and keeps a close watch over his property. A neighbor, who was convicted of having taken two trout out of his basins, was arrested by the cantonal police, and had to pay very dear for this transgression.

Since that time Mr. Massart has had nothing to fear from trespassers. Fishers who catch fish which have not yet attained their regular size must throw them into the basins of the establishment if they are alive; if dead, they are confiscated and given as food to other fish.

Mr. Massart has also made interesting experiments with a view of determining the influence of different waters on the development of fish. From the specimens which can be seen with him, one arrives at the conclusion that rapidity of current and fresh water are essential conditions for raising salmon.

In concluding our Swiss review we must briefly mention the establishment of M. de Loës, at Aigle, in the canton of Vaud, and the measures which the cantonal government has taken for replenishing their rivers.

M. de Loës, like Dr. Vouga, is a corresponding member of the Acclimatization Society. His experience is very valuable, and the federal government has understood this so well that it has intrusted to M. de Loës the entire administration of pisciculture in the canton; and, thanks to his exertions, there will soon be no lack of fish in the lake of Geneva, in the river Rhone, and the rivers of the canton.

At the request of M. de Loës, the government has established two fish-ponds at Lay, near the banks of the Rhone, where those fish are kept in reserve which are destined for reproduction. A government commissioner has to examine the fishing, and retains those fish which are to form part of this reserve. As fishing in this part of the river can only take place during the spawning-season, since salmon and trout only come there at that period, suitable fish are easily selected. Later, these fish are returned to their owners, who would lose all their privileges if they would refuse to submit to this arrangement. This excellent idea, somewhat modified, has been put into practice in two rivers of the canton of Vaud, the Thièle and the Arno, and the persons who rent the fisheries are obliged every year to deposit some fecundated eggs in the fish-ponds established near each of these rivers.

M. de Loës is subject to the same conditions as regards the canal running parallel to the Rhone, in which he is authorized to fish during the whole season. His hatching-establishment is well organized, and enables him to fill all the orders sent to him. After having procured all the fish he wants, he places them in his basins, waiting for the moment favorable for reproduction. The eggs are then placed on an apparatus, which receives water from an excellent spring in the mountains.

The hatching-process, which is always entirely successful, is conducted partly on sand and partly on clay.

The establishment for raising fish, located somewhat lower in the valley of the Rhone is fed from a very abundant spring, forming a brook, which M. de Loës has developed to the length of one kilometer, ($\frac{5}{8}$ of a mile,) by making it twist several times in a square, each side of which does not measure more than 100 meters, (328 feet.) Small lakes are

arranged at certain intervals, and deep and well-shaded holes serve as a place of refuge to large numbers of fish of every age.

The results obtained by M. de Loës are very remarkable; and this learned pisciculturist has not yet said his last word in the matter.

From time to time piscicultural meetings are held in the canton, in order to make known all the secrets of this new science, which is destined to be of the greatest importance for Switzerland. We must confess we would like to see this practice introduced in France.

Numerous societies have been formed, especially at Fribourg, through the exertion of M. de Boccard, and in the neighborhood of Aigle, of which I will speak in another place.

3.—ITALY.

The necessity for replenishing rivers has not yet been felt in Italy as much as in other countries of Europe. This country, on account of its geographical position, offers exceptionally fine opportunities for fishing, and the seas which surround it on nearly all sides supply all the wants of its population. As in Switzerland, so there are also in Italy, many lakes containing various kinds of excellent fresh water, but Switzerland has no sea-fishing, possessing only its lakes, which would soon be exhausted if they were not constantly being replenished.

The rivers and brooks of Italy are, with few exceptions, dry during a great part of the year. Those water-courses which never dry up entirely experience such a large increase of water at the time when the snow melts, that it would be useless and even imprudent to found piscicultural establishments.

They do to-day what they have done for centuries. At Venice as at Naples, nothing is changed. At Commachio the same plan is followed as that which has been so well described by M. Coste. In the cities of the Adriatic and the Mediterranean, Ancona, Beri, Brindisi, Civita-Vecchia, Leghorn, Genoa, &c., the resources of the sea are inexhaustible. But it is none the less true that the persons who are at the head of the administration fully understand the necessity of revising the fishing laws, and a project for doing this will soon be laid before the Italian Parliament.

In Italy also the laws have become insufficient for protecting the fisheries; and waste, the use of hurtful fishing instruments, and the consequent destruction of fish, have made protective measures necessary. There is only one step from this to understand the necessity of replenishing those rivers which offer favorable conditions for so doing; and sooner or later the government will be obliged to interfere in the matter.

4.—AUSTRIA.

Artificial pisciculture has only been introduced into Austria during the last eight years. The imperial government has taken the initiatory steps by founding on its domains hatching-establishments from which

every year many thousands of young fish are supplied to the lakes and neighboring rivers. The first establishment was that of Salzburg, founded in 1865. The government at first granted it a considerable annual subsidy, but for the last three years it has been able to cover its expenses, by raising from 10,000 to 15,000 young fish, and sending 3,000,000 of fecundated eggs to the different provinces of Austria, to Switzerland, Holland, and even to Hüningen.

At present every province of the empire possesses its own piscicultural establishment.

In upper Austria two societies have been formed, one at Linz in 1870, and the other at Ische in 1866; the former numbering 93 members, and the latter 29.

In the province of Salzburg the society has the name of "Central Institute of Artificial Pisciculture," and numbers 96 members.

In Tyrol a society was formed in 1869, consisting of 9 members; and another at Tarbole in 1873, numbering 42 members.

In Bohemia a society has been formed at Nachod, numbering 43 members.

In the province of Bukowina a society is being organized under the direction of M. L. Lindes, and the minister of agriculture has just granted him the sum of 800 florins.

We must here also mention the piscicultural establishments of the Princes Schwarzenberg, who have sent a number of specimens to the Vienna Exposition; the establishment of Baron Washington, the largest pisciculturist of Austria, at Wildon near Graz; and M. Pammer at Graz, who furnishes the river Murr with fish.

The Salzburg establishment, the largest of all, has been founded on the plan of the one at Hüningen. The hatching apparatus of the College of France is used in a somewhat improved shape. These apparatus hatch every year 3,500,000 eggs.

The establishment is located near the imperial castle at Salzburg, at the foot of the Alps, only two and a half miles from the city.

The basins to the number of fifteen are all fed by spring-water; they are partly covered so as to afford places of refuge for the young fish. The spring is in the house of watchmen and in the very place where the hatching takes place; a large basin of this fresh water surrounds the house, and in this those fish are kept which are destined for reproduction. The other basins, in which there are fish of every age, are comparatively small; that in which 20,000 young fish have been placed this year is only 2½ meters long, (nearly 4 feet,) 1 meter 20 centimeters broad, (about 3¾ feet,) and 35 centimeters (about 1½ feet) deep.

Two other basins are reserved, one for carp and the other for aquarium fish, which increase with an almost incredible rapidity, and being in proportion to the size of the establishment, whose area is about 30,000 square meters.

The food consists of white-fish and horse-flesh; and at the expense of about 2½ francs per day, 30,000 fish of all sizes are fed.

5.—Munich.

Bavaria has not remained behindhand, and pisciculture, which numbers many experts in that country, has made considerable progress. The fishing laws are very rigorous, but are very little regarded. The public markets are under strict superintendence, and considerable fines are imposed on those who repeatedly transgress the laws. The crawfish is numbered among that kind of fish whose capture is prohibited during the spawning season; females bearing eggs must again be thrown into the water, and none can be taken before they have reached their full size.

There are at Munich different establishments, that of M. Küffer affording great interest on account of the simplicity of its arrangement, the small space it occupies, and the great results obtained. I have there seen more than 200 trout, two years old, weighing on an average 350 to 450 grams (somewhat more or less than 1 pound troy) in a single stone vat $1\frac{1}{2}$ meters long, (almost 5 feet,) 75 centimeters ($2\frac{1}{4}$ feet) broad, and 60 centimeters (about $1\frac{3}{4}$ feet) deep.

In another compartment $2\frac{1}{4}$ meters (about 8 feet) long, $1\frac{1}{2}$ meters (almost 5 feet) broad, there are more than 6,000 crawfish, the finest of which weigh 250 grams (3,750 grains) and more.

Salmon to the number of six, and weighing on an average 10 to 12 kilograms (about 25 to 30 pounds,) are packed so closely in one of these small vats, that it is impossible for them to turn round; yet they do not seem to suffer from this position, which they have occupied for a long time. These remarkable results have been obtained by constantly renewing the water, and by providing good and abundant food.

The experiments of M. Küffer have been specially directed to the acclimatization of the *Salmo hucho*, a variety of salmon which is peculiar to the waters of Bavaria, and which after the experiments made by the College of France could easily be acclimatized in France.

This fish, which to the characteristics of the salmon adds the stationary habits of the trout develops in a very short time; it can be acclimatized in every water, and does not suffer from a change of temperature; it is easily fed with white-fish and salt horse-flesh, after a new system which has stood the test of experience. M. Küffer carries on all his hatching-operations on sand.

In Bavaria I have made some observations which deserve attention. A number of species which serve as food, and which are very scarce in France and Switzerland, are very common in the lakes and rivers of Bavaria; carp, pike, and perch are almost given away in the Munich market.

The question is naturally asked, why have those Bavarians who occupy themselves so much with pisciculture not endeavored to destroy the pike and perch, which are the sharks of the fresh water? I have learned the following regarding this matter. The pike and perch live

in rivers where there are no fish of the salmon kind, but only white-fish; and on the other hand, fish of the salmon kind, live in water which contains neither pike nor perch, but white-fish, on which they feed.

Unfortunately, this is not the case in France, where fish of prey are found in all the rivers, which to a great extent depopulates them. The necessity of a good law regulating the raising of these species is being more and more felt as an essential condition for successful pisciculture.

In France, we must confess, there has recently been a time when but little was done; this time has been filled, it is true, by the progress of some establishments founded in the Puy-de-Dôme, in the Pyrenees, in Creuse, in Savoy by M. Costa Bauregard, in the department of Haute-Vienne, &c., and by the interesting publications of De la Blanchère, Haxo, Millet, Jourdier, Wallon, Koltz, Carbonnier, Chabot, Maslieurat, the Viscount of Beaumont, Lamy, Chenu, Blanchard, and the various communications made to the Academy of Sciences, &c., besides the societies of oyster cultivators which have been formed, and whose services will be appreciated at no distant period.

Several general conferences have favored private enterprise by extending financial aid; this ought to be followed up, and new resources should be given to France.

The essential point, as M. Coste has shown, is to preserve by artificial fecundation that innumerable quantity of eggs which are lost before being hatched, or in an embryonic state. In order to carry on these experiments on a large scale and to furnish an abundant supply of this "manna" to serve as food for the human race, the government ought to found four large establishments in the four principal basins of France, into which the rivers of our country are divided, and which would develop pisciculture to its greatest possible degree.

A committee appointed by the government and composed of experts and engineers should examine the rivers, and in each basin designate the most favorable place.

These establishments would afford the advantage of replenishing the rivers of the country with those species of fish that could live there, and would endeavor to acclimatize those species which on account of the changes of temperature are not accustomed to live in our climate. These studies might be accompanied by experiments with apparatus and the different systems of raising fish, and all these different experiments should be under the control of the College of France. The programme should embrace the influence of the nature of the water on the development and acclimatization of different species, experiments which are impossible in laboratories, which are generally only supplied with water of one kind; the different systems of food should also be studied. The administration of bridges and roads would, on account of its admirable organization, be naturally destined to be at the head of this whole undertaking and superintend it.

The reason that France has not advanced so rapidly in pisciculture as one had the right to expect after the convincing experiments of M. Coste, is that great ignorance prevails regarding the means to be employed. Many well-meaning persons have made and are making experiments yielding only a partial result. This is very obvious; not knowing the well-known processes, they are obliged to try everything, to learn everything, and to do a great deal by guess-work; those who are not discouraged after experimenting for two years, do not always possess the means to meet the new expenses which would be required. If they could acquire the knowledge they are in want of in model-schools of pisciculture, such as these four great establishments mentioned above would be, in the same way as the agricultural farm-schools, they would be sure to succeed, and would not shrink from sacrifices for which they would most assuredly in the end reap their reward. These model-schools would doubtless be a great success and would greatly increase the resources of France.

6.—THE GREAT BASINS OF FRANCE.

The basin of the Seine, which measures 4,327,000 hectares, (10,817,500 acres,) on an area of 800 kilometers, (500 miles,) and which is watered by the Aube, the Marne, the Oise, the Yonne, the Eure, &c., offers a most favorable location for the first of these establishments, viz, the basin of Settons, located in Morvan, and proposed by M. Coste.

In the basin of the Loire, which comprises one-fourth of France, and whose principal tributaries, the Mayenne, the Sarthe, the Allier, the Cher, the Indre, and the Vienne, traverse more than 1,100 kilometers, (687 miles) it would be easy to place a second piscicultural establishment, either between Orléans and Tours, or near Clermont-Ferrand and the neighboring lakes, especially Lake Pavin, called the "Dead Sea" of Auvergne.

The third establishment should be placed in the basin of the Garonne, the Dordogne, and the Gironde, to which the secondary basins of the Charente and the Adour would belong.

As regards the basin of the Rhône, whose course in France is 520 kilometers, (325 miles,) the fourth establishment ought to be placed above the junction of the Rhône and the Saône.

The *féra*, (*Coregonus fera*,) found in large numbers in the Lake of Geneva, through which the Rhône flows, could be acclimatized in the waters of Bourget, or in the lakes near the Puy-de-Dôme. What a fine field for experiments could be opened to human industry in France, and what immense resources could be opened for supplying the people with food!

The following conclusion is easily reached: By the side of the laboratory of comparative embryogeny of the College of France, from which most of the physiological prizes come which are given by the Academy of Sciences, the Laboratory of Pisciculture is placed, which, up to the

present time, has always given information and advice, and which popularizes the progress which science makes every year.

The four establishments which we desire to see founded would not cost more than the single establishment at Huningue, and would spread a knowledge of and a taste for pisciculture; it would be their duty to apply practically all the discoveries which have been made; they would spread life and abundance in the four great basins of France; they would greatly develop the river-fisheries, and would create the necessary regulations; they would replenish with fish the Seine, the Loire, the Garonne, the Rhône, and their tributaries; they would point out the species most suitable for each part of the country, and would open out vast resources of private industry by the founding of smaller establishments.

This is the object we aim at, with good chances for success, and which we will doubtless obtain if the government will aid us in our efforts.

D—THE PROGRESS OF FISH-CULTURE IN THE UNITED STATES.

By James W. Milner.

1.—THE METHODS EMPLOYED IN FISH-CULTURE.

There are three methods in use for the increase of fishes; the first two employed from a very early day, and the other of quite recent origin. As all of these methods have been applied in the United States we will consider them in order. The first is the transfer of living fishes from their natural haunts to new waters, or to a confined area in their own stream, lake, or arm of the sea, where they are either left to depend on such food as the water may afford, or else are supplied with it from elsewhere.

The second method is the gathering of eggs naturally impregnated and deposited, and placing them in ponds or streams, or caring for them during the period of incubation in suitably-arranged apparatus.

The third method, and the one by which the more important results have been attained, consists, primarily, in the artificial fecundation of the ova, (expressing the eggs and milt from ripe fishes together in a vessel;) and secondly, in caring for them in suitably-devised apparatus through the egg-stage, and as far along during the embryonic life of the fish as their welfare requires, when they may either be turned out to shift for themselves, or else kept in properly-arranged ponds or otherwise, and fed as occasion requires for an indefinite period of time.

It has been quite a usual habit in writing on the subject of fish culture to attribute the origin of the art to the Chinese, and many have been led to believe from the frequent assertions to that effect that the artificial fecundation of fish eggs was practiced by the Chinese, who

thus anticipated the Europeans. The principal data relating to fish propagation in China are to be found in the publications of the *Société d'acclimatation* of France, and in a large work published in Paris in 1872 entitled "*La pisciculture et al pêche en Chine*," by P. Dabry de Thiersant, with an "*Introduction sur la pisciculture chez les divers peuples*," by Dr. J. L. Soubeiran. A "History of the Chinese Empire," by Father Duhalde, a Jesuit missionary, also contains a reference to pisciculture. Special inquiries have also been made by Mr. George Shepard Page, of New York, through the State Department, and satisfactorily answered.

All authorities agree with reference to the antiquity of the practice by the Chinese of the first two methods described, but no evidence is produced that they have now or ever had any knowledge of artificial fecundation of the eggs of fishes as employed by Europeans.

At the present day a certain class of the Chinese devote their time at the proper season of the year to the capture of quantities of embryo fishes, which are carried to ponds, streams, and lakes, and turned loose in their waters to increase their stock of fishes. These embryos are found in holes or pockets in the beds of the rivers, and are obtained by divers. Ova are also obtained in large quantities in the rivers, by straining the current through nets or mats, and intercepting the eggs as they are carried down stream.

2.—TRANSFER OF LIVING FISHES.

The pike or pickerel.—The transfer of fishes early gained the attention of the people in this country as well as in Europe, and it is a singular coincidence that in Central Europe as well as in different parts of the United States the same species, the lake pike, or pickerel, (*Esox lucius*,) received favor in this direction, both countries having afterwards had reason to regret its distribution. This fish, the merits of which are sometimes defended in regions where it is the principal species, is not only very destructive of other fishes, but is of indifferent flavor and full of bones.

In Maine, New Hampshire, and other States its introduction is now regarded as a mistaken enterprise, and the same expressions of regret that are found in the reports of the fish commissioners of some of the States, at its distribution in the waters, occur in papers on the fishery interests of Germany, and in certain English publications.

The disposition to introduce this species into new waters has been recognized, and its fatal error is so well understood that in some of the States laws have been enacted inflicting a fine upon any one convicted of having introduced the pickerel into waters where it does not exist.

The muskellunge.—About 1840 this species (*Esox nobilior*) was placed in a pond near Bellows Falls, Vermont, from which it escaped into the Connecticut River, and has maintained its presence ever since.

The black bass and Oswego bass.—The fish that before the days of artificial fecundation of fish eggs have been perhaps the most extensively introduced are the black basses of the species *Micropterus salmoides* and the *Micropterus nigricans;* the former being the one better adapted for clear streams and lakes, and the latter for grassy and comparatively shallow lakes and ponds. Mr. Thaddeus Norris relates in his volume on American angling that when a boy he knew of the stocking of a pond in the vicinity of Richmond, Va., with the black bass, (*Micropterus salmoides.*) Among numerous records of their introduction, in very few instances discriminating properly between the two species, we give the following: In 1850 twenty-seven live bass were brought by Mr. Samuel Tisdale, of East Wareham, Mass., from Saratoga Lake and put into Flax Lake, near his home. In the years 1851 and 1852, others were brought to the number of two hundred and reared in ponds in the vicinity. The matter was kept quiet and fishing discouraged for five years, when the fish were found to have increased very rapidly. Some twenty-five ponds were stocked in the same county after Mr. Tisdale had initiated the experiment. Afterward black bass from Mr. Tisdale's ponds were supplied to a lake in New Hampshire in 1867, and to waters in Connecticut and Massachusetts. In 1866 the Cuttyhunk Club, of Massachusetts, introduced the black bass into a pond in their grounds. In the year 1869 the commissioners of the State, together with private parties, stocked several ponds and the Concord River with black bass, and in the following year other waters were stocked.

In Connecticut, in the winter of 1852–'53, the black bass was introduced into Waramang Lake, in Litchfield County. They were brought from a small lake in Dutchess County, New York. A few years later they were said to have increased greatly. Another lake in the same county was stocked not long afterward.

Saltonstall Lake, near New Haven; East Hampton Pond, in Chatham; Winsted Pond, in Winchester, and many ponds and lakes of the State, particularly in the northwest portion, were stocked with the black bass previous to the year 1867.

In the years 1869, 1870, 1871, and 1872, thirty-seven lakes and ponds in different parts of the State were supplied with black bass.

As early as 1864 or 1865 black bass had been put into Rust's Pond, near Wolfborough, New Hampshire; in 1868 a few were brought to Charlestown and lakes Massabesic, Sunapee, Pennacook, and Echo, and Enfield, Wilson's, and Cocheco Ponds were well stocked; in 1870 and 1871 the New Hampshire commissioners introduced the black bass from Lake Champlain into the waters of the State at Meredith, Canaan, Webster, Canterbury, Harrisville, Munsonville, Hillsborough, Warner, Sutton, New London, Andover, Loudon, Concord, and in Croydon. In Massabesic and Sunapee Lakes, where they had been introduced, in 1868 and 1869, they were found to have increased, and, on the authority of Dr. W. W. Fletcher, they have become exceedingly numerous in Sunapee Lake.

The commissioners of the State of Rhode Island, since 1870, have stocked thirty ponds or small lakes in different parts of the State with the black bass.

In Maine, in the fall of 1869, the State commissioners and the Oquossoc Angling Association introduced from Newburgh, N. Y., a quantity of black bass. The waters of Duck Pond, at Falmouth; Fitz Pond, in Dedham; Newport and Phillips Ponds, Cochnewagan Pond in Monmouth; Cobbosseecontee Lake, in Winthrop and adjoining towns, were stocked, and a few years afterward were reported to have increased largely in numbers.

Since the year 1871 black bass (*Micropterus salmoides*) and Osweg, bass (*Micropterus nigricans*) have been put into seventy lakes, ponds, or streams of the State of New York by the commissioners. They had made their way of their own accord through the canals connecting Lake Erie with the Hudson into that stream.

Private citizens of Pennsylvania introduced the black bass (*Micropterus salmoides*) into the Susquehanna about 1869, at Harrisburg. In 1873 the tributaries of the Susquehanna, the Potomac, and Delaware Rivers were supplied with black bass by the commissioners at thirty-five different points.

In the year 1854 Mr. William Shriver, of Wheeling, Va., planted in the canal basin at Cumberland, Va., his former home, a number of the black bass, (*Micropterus salmoides*;) from the basin they escaped into the Potomac River, where they have increased immensely at the present day. They were moved from the waters of the Ohio River to their new locality in the tank of a locomotive. Numerous cases have also occurred of transfer from one locality in the Southern States to another.

There have been very many transfers of these valuable species that have not been recorded, as they are easily kept alive while being moved from one place to another, and propagate surely and rapidly in ponds, lakes, and rivers.

These details are given because they show the facility with which comparatively barren waters may be stocked to a considerable extent with good food-fishes, and they exhibit the general interest and attention that have been given to this mode of propagation.

The wall-eyed or glass-eyed pike.—The wall-eyed pike (*Stizostedium americanum*) is another species that has received favor for this purpose. It is a fine-flavored fish, somewhat predatory in its habit, and not so generally adaptable to waters of all characters as the black bass. In the great lakes and rivers, where it finds a favorable home, it multiplies to a much greater extent than the latter species. It had been introduced in some of the lakes of New Hampshire, New York, and other States.

The eel.—The eel, (*Anguilla bostoniensis*,) appreciated in some localities and much vilified in others, is another species that has been frequently transplanted. It is pretty evident that it never existed naturally in the

chain of great lakes any higher up than Niagara Falls, although specimens have been taken in Lakes Erie and Michigan. Their existence there is with little doubt traceable to artificial transportation.

A captain of a lake-vessel informed me that it was quite a common thing, some years ago, to carry a quantity of live eels in a tub on the deck of a vessel while on Lake Ontario, and they were often taken in this manner through the Welland Canal. He said that it was a frequent occurrence on his vessel when they had become tired of them, or had procured better fishes, to turn the remainder alive into the waters of Lake Erie.

In 1871 Mr. A. Booth, a large dealer of Chicago, had an eel of four pounds weight sent him from the south end of Lake Michigan, and a few weeks afterward a fisherman of Ahneepee, Wis., nearly two hundred miles to the northward, wrote him that he had taken a few eels at that point. It was a matter of interest to account for their presence, and a long time afterward we learned that some parties at Eaton Rapids, Mich., on a tributary of the lake, had imported a number of eels and put them in the stream at that place, from which they had doubtless made their way to the points where they were taken. The unfortunate aquarium-car in June, 1873, by means of the accident that occurred at Elkhorn River, released a number of eels into that stream, and about four thousand were placed by the United States commission in the Calumet River at South Chicago, Ill., two hundred in Dead River, Waukegan, Ill., and three thousand eight hundred in Fox River, Wisconsin.

The alewife.—The alewife (*Pomolobus pseudoharengus*) has in numerous instances been largely multiplied by carrying the parent-fish above the dams that prevented access to their favorite spawning-grounds, or even to new waters. According to General Lincoln, an experiment of this kind was made successfully as long ago as 1750. This has been a common practice in the shorter rivers on the Massachusetts coast, generally with good results.

The smelt.—The introduction of the smelt (*Osmerus mordax*) into new streams and lakes has been attempted by New Hampshire and Massachusetts. In New Hampshire three lakes were stocked in 1871, and in Massachusetts it is said that Jamaica Pond was stocked near the close of the last century, and that they have existed there ever since, without access to the sea. In 1869 they were introduced by the commissioners into Flax Pond, in Wareham.

The white fish.—Mr. L. J. Farwell, of Madison, Wis., formerly governor of the State, transferred in 1854 a number of white fishes, (*Coregonus albus*,) together with the brook-trout, (*Salmo fontinalis*,) to the lakes around Madison. As the white-fish are only taken with nets their presence in the lake was only manifested when suitable nets were made use of. Elizabeth Lake, in Oakland County, Michigan, was stocked with this

species many years ago, and it has since increased to a very large extent, and affords a considerable income to the owners of the property on the lake who control the fisheries.

The salmon or *lake trout.*—A considerable number of this species, (*Salmo namaycush*,) obtained in Lake Ontario was introduced into Newfound Lake, New Hampshire, in 1871, by the State commissioner. In 1866 a number of land-locked salmon, (*Salmo sebago*,) had been brought to this lake from the St. Croix River.

The brook-trout.—The brook-trout, (*Salmo fontinalis*,) the favorite of anglers, has, of course, received much attention in this direction.

There are numerous instances related of their being introduced into new waters from neighboring streams. Even in the interior of the country they have been transferred southward among the drift ridges and prairies from the more northern rocky streams of Michigan, Wisconsin, and Minnesota. Generally this has been done for the purpose of stocking breeding-establishments.

A stream at Lake Forest, in Northern Illinois, flowing from an artesian well, was supplied with live trout brought from Wisconsin, but none of them lived, probably because of the high temperature of the water. The distribution of this species from breeding-establishments has been very extensive.

3.—THE TRANSFER OF NATURALLY-DEPOSITED EGGS.

Spawning races.—Of the second method there has been comparatively little application in the United States.

The experiments in hatching black bass by placing the pairs in a box similar to the one used by Lund in 1760, and the methods employed for obtaining trout-spawn originated by Ainsworth and Collins, are of this character.

The simple apparatus employed by Mr. Ainsworth was merely an adjustable section in a narrow raceway constructed in such a situation as would induce the trout to enter from the deeper water for the purpose of digging their nests. A screen of coarse-wire cloth covered loosely with gravel constituted a false bottom to this box, through which the eggs, on emission, fell to the real bottom below.

The Collins apparatus was an improved modification of this principle, inasmuch as it obviated the necessity of disturbing any portion of the raceway, the eggs falling through the upper screen upon a revolving apron, or wide belt of wire cloth beneath, when, by turning the drums on which it rolled, the eggs were carried to one end, and fell over into pans placed to catch them.

The greater percentage of fertile eggs from artificial impregnation has induced, in later years, very little use of these methods, except where it is regarded as desirable to avoid the cold and often severe exposure to the person impregnating eggs in cold weather.

Hatching from the offal of dead fishes.—There exists quite a prevalent notion that the stock of fishes may be protected from diminution to a considerable extent by returning the offal from fishes dressed for salting, containing the ovaries and spermaries, to the waters from whence the fishes are taken. This is done to a large extent at Sandusky, Ohio, on Lake Erie, where the white-fish (*Coregonus albus*) is taken in large numbers in the spawning-season, and the fishing-grounds are so far off from the curing-houses that but little damage is done by the presence of the decaying matter.

That the ova from fishes dead for a short period of time may be fertilized and hatched has been proven by experiment by embryologists and fish-culturists.

Jacobi, in his early experiments, found that young fishes could be developed from the eggs and milt of fishes recently dead.

M. de Quatrefages, in referring to the fertilization of fishes, says the fecundation should follow soon upon the death of the male fish, and the second clause of his directions says, "Since the fecundation should take place within a day or twelve hours after the death of the fish, the spawn should then be taken."

In Carl Vogt's essay on artificial fish-breeding he says, in speaking of the fertilizing power of the spermatozoa: "At low temperatures this power is retained for hours and even days if the milt remains in the organs by which it is secreted. In the Lake of Neufchatel (Switzerland) the paleé, (*Coregonus palea*,) a fish of the trout family, is taken, during the winter months, by night or at sunset. I have often received these fish stiff-frozen, and succeeded perfectly in impregnating spawn with the milt taken from the genitals of the male the day after."

On page 497 of this report is a reference to the success the Russian fish-culturists have had in hatching the eggs from dead females impregnated with the milt from dead males, the claim being made that the milt retains its vitality for a long time if left within the reproductive organs.

Mr. Atkins (see pp. 285–'86) gives the percentage of eggs fecundated taken from dead females, as follows: From a salmon that had been dead two hours, at .58½; of eggs from two dead females, at .67½; of eggs from two dead females, at .35; of eggs from dead fish, .92½; of eggs from dead fish, .30; of eggs taken from dead fish the day before, .12½; of eggs taken on November 11 from specimens killed on the 9th, .0; from a fish that had been dead fifteen hours, .0. The experiments with eggs from live females, to which the milt from dead males was applied, gave the following results: Female ripe and good, milt, about a teaspoonful, from a dead fish taken before the eggs, .2½; eggs kept in a pan without water thirty hours, milt from a male that had been dead two days, .0; from eggs kept the same length of time, treated with fresh milt, .87½; eggs kept without water four days, milted with milt from dead fish, .0; eggs kept four days without water, then milted with new milt, .12½.

The indications from these few experiments are that the eggs retain their vital powers much longer than the milt within the dead bodies of the fish.

The experience of fish culturists is certainly in favor of the immediate use of the milt from the living male fish, their experiments indicating that the vitality of the milt continues for but a few minutes when diluted with water, and even undiluted its certainty of effect rapidly decreases to zero.

That eggs and milt retain sufficient vitality when removed from fishes but a short time dead to produce a living embryo may be true, but there is also quite a possibility that there would be less vigor in the embryos and in the growing fish than in the case of eggs and milt from a live fish.

One of the investigators of the incipient embryonic development, studying the process in the amphibia,* as one of his conclusions, makes the following statement: "Partial impregnation is shown in imperfect segmentation of the yelk, and is due to the spermatozoa being insufficient in quantity, or in duration of contact, or inefficient through diminished vitality; and it may also result from diminished susceptibility in the ovum." It will readily be admitted that some of these unfavorable conditions are very liable to occur when the spermatozoa or ova from dead fishes are used.

The small per cent. of fishes produced from a quantity of eggs where there is the slightest lapse of care and attention on the part of the breeder is convincing evidence to all who have had even a slight experience that no large results could be expected from this practice. Where the fishes are taken near the curing-houses and are dressed within a short time after death, in all probability a small portion of the ripe eggs would develop into fishes; but in localties where many of the fisheries are situated, the fishing-grounds are so far away that the fish are dead for several hours before they reach the shore, and the percentage of fishes produced from the spawn would be very small, if anything.

4.—ARTIFICIAL FECUNDATION.

Introductory remarks.—The evidences advanced to prove a knowledge of the third method referred to, before the time of Jacobi, are not, so far, sufficiently definite, and the data produced by Baron de Montgaudry to show that Dom Pinchon was the inventor of the art, in so far as it involves artificial fecundation, are very unsatisfactory.†

The description he gives of the apparatus proves Dom Pinchon's process in caring for the eggs during the period of development to have been the

* On the Impregnation of the Ovum in the Amphibia, and the direct agency of the spermatozoon; Proc. Roy. Soc. June 17, 1852, George Newport, F. R. S., &c.

† Bulletin de la Société Zoologique d'Acclimatation. Fondée le 10 Février, 1854. Tome premier. Paris, 1854, p. 80.

original of the trough method. The manner of procuring of the eggs is not referred to; he merely explains how he prepared the bed of sand upon which to deposit the eggs which he had previously made fecund.*

The baron based his statements upon the manuscript found at Reome, without quoting from it, and leaves his readers in ignorance as to whether the mode of obtaining the eggs is described in the original.

In the absence of any publication of the manuscript the only data to support the claim are the statements made by Baron Montgaudry and the reference in a foot-note of Jules Haimé's paper on pisciculture (see page 472) to the method employed for obtaining the eggs; this information on the subject afforded by Baron Montgaudry, and referred to in the foot-notes, was probably imparted in conversation, as there is no record of it in the papers published in the Bulletin or in the report of the *Procès-verbaux des séances* of the society from the time of Montgaudry's references to Dom Pinchon to the date of publication of Jules Haimé's paper.

The publication of the manuscript, if it is still in existence, would clear up the uncertainty and afford a definite record for the history of this important advance in the art of fish culture.

To J. L. Jacobi, lieutenant of Lippe-Detmold, a German principality, belongs the credit of discovering and making public in a journal published in Hanover in 1763, the methods in the art of fish culture now used in modified and improved form.

The description of his box accords in general form and proportions with the trough in modern use. It was 12 feet long, 6 inches deep, and 18 inches wide. It lacked the cleat partitions now used that divide the troughs into nests, the eggs being sheltered from the force of the current by hollows and cavities in the bed of gravel in which they collected. The water supplied to the trough flowed through a screen or grate of brass wire, and the outlet was guarded by a similar screen. The screens would be considered of rather large mesh for use in the hatching establishments of the present, as they were about eight wires to the inch. Jacobi regarded covers to the troughs as a necessity, but not for the purpose they are now deemed essential. There is no evidence from his letter that any building or roof was thought of in connection with his troughs, and tight covers were necessary to protect the ova from their natural enemies, the one he most dreaded being the water shrew; this use of a screen under the supply-stream being more with regard to protection from this animal than for the purifying of the water.

Spring-water from a rocky, pebbly locality he considers to be the best. The supply of water to each trough, he asserts, should be an outflow of a pipe one inch square, with one or two feet head, and should

* Il préparait une légère profondeur dans la couche de sable pour déposer les œufs, qu'il avait préalablement fait féconder.

cover the gravel one or two inches deep. In the use of several troughs he provides for a main pipe, conducted across the head of the troughs, with outflows into each. "This done, you have all the apparatus necessary for breeding trout and salmon."

Jacobi understood that only a small quantity of the milt was necessary, because it contained vast numbers of the spermatozoa, and would fertilize a large number of eggs.

His manipulation of the male and female trout, stirring the milt through the eggs, and the addition of fresh water after impregnation of the eggs, is very similar to modern practice. The necessity of separating the eggs in the troughs was well understood, though, instead of a feather, he, by means of a thin paddle of wood, produced an eddy in the water that spread the eggs over a larger surface. The fine, downy fringe of the conferva growth was a difficulty he had to contend with as well as modern workers in the art, and the little trout of ancient times had the same tendency to hide themselves in the gravel when young that they do at this day.

His gratings did not prevent the egress of the young fishes, and he provided them with nurseries at the end of the troughs. Monstrosities, in the shape of double-headers, he seems to have been familiar with, and found them short-lived.

Jacobi seems to have been a man of intelligence and application. Some of his conclusions, however, have since been entirely disproven by investigators in embryology.

The progress made in the methods and apparatus of fish culture has been very great, as the result of the experience of many experts, and in certain lines is entirely new and novel; but the present graveled trough method for hatching trout and salmon is only an improved modification of the boxes and troughs used by Dom Pinchon and Jacobi.

The necessity of filtering the water through screens, the advantage afforded by dividing the troughs into nests, by means of cleats, so that the bed of gravel may be kept level, and prevent the tendency of the eggs to collect in heaps, the shutting out of light from the eggs, the immense reduction of loss from the removal of dead eggs and fungus growth, the transportation of partly-developed eggs, and feeding young fish with prepared food, were all entirely unknown to the earlier authors; as also the numerous improvements in the manipulations, the guarding against the ills incident to the eggs and young fishes, that have grown up in the experiences of the numerous workers in the art. Jacobi, indeed, does not seem to have carried forward his discovery to any extensive practical result, although an establishment at Nortelem was sustained for a short time, and the English government had sufficient appreciation of his work to afford him a pension.

Adanson, in a course of lectures delivered in Paris in 1772, made the statement to his auditors that the art of fish culture was prosecuted with success on the river Weser, in the Palatinate of the Rhine, and in some of the higher mountainous portions of Germany.

The Abbe Spallanzani, an Italian, in 1768, employed artificial fecundation in his studies of the embryology of the frog, and Monro Rusconi, also an Italian, in 1824, artificially fecundated and hatched the eggs of a cyprinoid fish, the tench (*Tinca vulgaris*) while prosecuting investigations in embryology.

In 1837 John Shaw practiced the art with the salmon in the river Nith of Scotland, and made use of his experience to extend the knowledge relating to the growth and development of the young salmon.

Joseph Rémy, a fisherman of the department of the Vosges, France, discovered and applied, about 1842,* the methods of artificial fecundation on the trout. Afterward uniting with him Antoine Gehin, they continued the work with ample success in the rivers of their region. It was from the work of Rémy and Gehin that the great impetus and extended efforts in fish-culture had an origin, when it had been brought to the notice of the world by the French scientists.

The artificial propagation of fishes is now extensively practiced in Great Britain, France, Belgium, Holland, Denmark, Norway, Sweden, Russia, Germany, Hungary, Switzerland, Italy, and Spain, in Canada and in our own country, while India, Java, Australia, and Tasmania have instituted investigations by fishery commissioners and have imported valuable species of food-fishes.

In the United States the first published record of an experiment in artificial fecundation was made by the late Rev. John Bachman, D. D., the naturalist, of Charleston, S. C., who was associated with Audubon in his work on the quadrupeds of North America.†

In 1855 he read a paper before the State Agricultural Society, at Columbia, S. C., describing his successes when a boy, in the year 1804, in impregnating and hatching the ova of the *corporal*, probably the *Semotilus corporalis*, (known in Pennsylvania as the fall fish,) and of the trout, (*Salmo fontinalis.*) In his paper he states that the eggs of both species were artificially fecundated and hatched, and that the trout attained some growth while confined in the ponds he had constructed.

The trout was the fish selected in the United States from the first as the favorite for artificial culture. In 1853 Theodatus Garlick, M. D., and Prof. H. A. Ackley, of Cleveland, Ohio, incited by their knowledge of the interesting results of the fish-culturists in France, began an experiment with the brook-trout, (*Salmo fontinalis*,) in which they were quite successful. In 1857 Dr. Garlick published a treatise on artificial propagation of fishes, appearing first in a series of numbers of the Ohio Farmer, and afterward gathered into a volume.‡

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* See the foot-note referring to the claim of Gottlieb Boccius, to have preceded Rémy in the practice of artificial fecundation, on page 477.

† The Viviparous Quadrupeds of North America, by John James Audubon, F. R. S., and the Rev. John Bachman, D. D. New York: Published by J. J. Audubon, 1846, 4to.

‡ See title at foot of page 536.

To these gentlemen should be ascribed the merit of inaugurating the interest in fish-culture in this country.

Mr. E. C. Kellogg, of Hartford, Conn., and Mr. D. W. Chapman, of New York, began breeding operations at Simsbury, Conn., as early as 1855, and published their results before the Connecticut State Agricultural Society in 1856. A number of trout were captured and confined, the eggs fecundated and placed in boxes with gravel on the bottoms, through which a stream of water was led. At this first attempt seventy-five trout were hatched; some of them were taken from the pond the next season. In 1856 Mr. Kellogg's efforts were not very encouraging, because, as he believed, the eggs were not sufficiently mature, and arrangements for hatching in the cellar of his house at Hartford were imperfect. In 1857, with the apparatus in his cellar, and using water from the regular city supply, he hatched four hundred trout. In 1859 Colonel Colt, of revolver fame, made very complete arrangements for trout-hatching, of which Mr. Kellogg took charge, and about four thousand eggs were impregnated and placed in the hatching establishment

In 1857 the State of Connecticut passed an act affording certain powers and control of Saltonstall Lake for the purpose of fish-breeding, and increase in the interest of Mr. Carl Muller, of New York, and Mr. Henry Brown, of New Haven. They also obtained certain riparian privileges from the owners of property bordering on the lake. A stream tributary to the lake was selected as the breeding locality.

In May of the same year they are said* to have artificially fecundated twenty millions of eggs of the wall-eyed pike, (*Lucioperca americana*,) and to have transported them from Lake Ontario to the lake, where they were placed in the bed of the stream referred to and on the lake bottom, but the young fishes were all supposed to have been destroyed by a sudden freshet.

In November of the same year they visited Lake Ontario, and taking males and females of the salmon trout, (*Salmo namaycush*,) and the white fish, (*Coregonus albus*,) alive from the nets of the fishermen, they impregnated a large number of eggs, estimated by them at five millions for the trout, and one million for the white fish. They were packed in alternate layers with fine, wet sand.† The eggs were said to have the appearance of being in good condition when they arrived and were deposited, the white fish ova upon the sandy spots and the trout ova upon gravelly places in the stream-bed. In the March and April following the young were said to have been seen in large numbers.

In the autumn of 1858 ten millions ova of trout and white fish were again obtained and placed in the lake and stream, and considerable numbers were believed to have been hatched. Trout are said to have been taken afterward partly grown.

* Report of the Commissioner of Patents for the year 1859. Agriculture, Washington, 1860. Article fish-breeding, by J. C. Comstock, of Hartford, Conn., p. 227.

† Probably largely overestimated in both cases.

In 1859 Mr. Stephen H. Ainsworth, of West Bloomfield, N. Y., began operations with the brook-trout in a small stream and with good success. His successes and his generous spirit toward all who visited him, or sought information by letter, have largely influenced the spread of the interest throughout the country.

Seth Green's establishment, at Caledonia Springs, near Rochester, erected in 1864, was the first hatching-house in this country large enough to prove the importance of fish-culture as a pecuniary investment. It took but a short time to establish the fact, and from the interest excited, by his very marked successes, among the newspapers and magazines, the art obtained its great impetus in this country.

The brook-trout.—As stated, attention was at first, and it is equally true that it remained for a long time, concentrated almost entirely upon the brook-trout, (*Salmo fontinalis.*) This fish is a general favorite, because it combines all the desirable qualities demanded by sportsmen, epicures, and others. It has beauty of color, form, and movement; is adapted to scientific fly-fishing, being sufficiently shy to be tempted only by skillful and experienced anglers, and, when hooked, fighting long and pluckily against the attempt to lift it from the water, and, withal, superior in flavor, moderately prolific, and adapted to small streams and ponds if sufficiently cool, so that owners of such waters may have it as a possession almost as much under their control as their cattle or horses.

This general demand for the living fish has made it much more profitable than if merely propagated as an article of food, as the sale of ova and young fishes bring better prices with smaller outlay than where the fish are retained and fed and cared for until they are mature.

That it is possible to raise them profitably merely as an article of food has, however, been established in one or two instances where the facilities for breeding large numbers and procuring their proper food in abundance and cheaply have been afforded.

The breeding of trout among the different and widely separated culturists does not seem to have developed lately any marked or novel improvements in apparatus, though valuable modifications of methods have been attained.

The graveled troughs are in most general use, though a few prefer the apparatus invented by M. Coste, professor of embryology in the College of France, the Coste hatching-trays, with glass grilles or parallel rods, upon which the eggs are placed.

As already stated the advances in the art of fish-culture in general both in America and in Europe, have been largely the result of efforts at multiplying the brook-trout of the two countries respectively. Whether we consider Bachman or Garlick as first to initiate the work in the new world, it was with the trout that the labors of both were connected. A comparison of the claims of these pioneers may result in giving Doctor Bachman the priority in time, but his labors have had little or no influence in developing interest in or adding to the knowledge of the

art. In fact, the doctor, who is remembered by his friends and acquaintances as a man of amiable qualities and modesty of disposition, makes no claim to having published any account of the matter prior to 1855, two years after Doctors Garlick and Ackley had begun their work.

An account was first given by Doctor Garlick, in the Ohio Farmer, of the methods of trout-breeding employed by himself and Doctor Ackley within two or three years after beginning their experiments; and in 1857 these papers were reproduced as a manual,* which has had a wide circulation. Their experiments with the trout, as also those of S. H. Ainsworth in 1859, were of the utmost importance in initiating the interest in pisciculture in the United States.

Seth Green began the famous establishment near Rochester, N. Y., in 1864, and from the first exhibited especial capacity and genius for the art. More than those of any other person in the United States, his labors have popularized the subject and extended the new industry throughout America, at the same time greatly improving and perfecting methods of work. In 1870, he published in connection with Mr. A. S. Collins, a manual of trout-culture,† which is still in demand.

In 1867, Dr. J. H. Slack purchased the establishment at Bloomsbury, N. J., founded by Thaddeus Norris, author of a work on fish-culture,‡ and who as far back as 1865, in his book on angling,§ devotes a chapter to fish-breeding.

Doctor Slack built up a successful establishment in a few years, and in 1872 published a manual || on trout-culture, which contained the most correct history of the prosecution of the art in the United States that had been written, and a list of the works in the French and English languages, relating directly to practical fish-culture. His knowledge of

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* A Treatise on the Artificial Propagation of Certain Kinds of Fish, with the description and habits of such kinds as are the most suitable for pisciculture, by Theodatus Garlick, M. D., vice-president of the Cleveland Academy of Natural Science, giving the author's first experiments contained in a paper read before the Cleveland Academy of Natural Science; also directions for the most successful modes of angling for such kinds of fish as are herein described. Cleveland, Thomas Brown, publisher, 1857.

† Trout-Culture, by Seth Green, published by Seth Green and A. S. Collins, Caledonia, N. Y. Rochester, N. Y., 1870.

‡ American Fish Culture, embracing all the details of artificial breeding and rearing of trout, the culture of salmon, shad, and other fishes, with illustrations. New York; 12 mo., 1869.

§ The American Angler's Book, embracing the natural history of sporting fish and the art of taking them, with instructions in fly-fishing, fly-making, and rod-making; and directions for fish-breeding, to which is added Dies Piscatoriæ, describing noted fishing-places and the pleasure of solitary fly-fishing. New edition, with a supplement, containing descriptions of salmon rivers, inland trout fishing, &c., &c. By Thaddeus Norris. Illustrated with eighty engravings on wood. Philadelphia, E. H. Butler & Co.; London, Sampson, Low, Son & Co., 1865.

|| Practical Trout-Culture, by J. H. Slack, M. D., commissioner of fisheries of New Jersey; natural history editor of "Turf, Field, and Farm," New York; proprietor of Troutdale Pond, near Bloomsbury, N. J. "We speak that we do know and testify that we have seen." New York: George E. Woodward; Orange Judd & Co., 245 Broadway, 1872.

French enabled him to gather in the valuable points in the experience of French culturists, which, in the true scientific spirit, he imparted to the public.

Doctor Slack invented a vessel for the transportation of fishes, which he called the "Troutdale transit-tank." This is a can of galvanized sheet-iron, holding ordinarily about twelve gallons, having a pan with a perforated bottom fitting into the top, to contain ice for the purpose of reducing the temperature of the water. In the top of the pan is inserted a high cover, having windows of perforated tin, surrounded by a belt or cylinder of the sheet-metal, arranged with openings corresponding to the windows, so that drawing the belt for a short distance around the top closes them. On the outside an air force-pump is attached, with a hose leading through the bottom of the tank to a rose that divides the air into fine particles before it ascends through the water, thereby aerating it in a most effective manner. This is a most invaluable arrangement where fresh supplies of water are difficult to obtain. This apparatus is described in his manual with an illustration, and its use tendered to the public, no patent having been secured upon it.

In 1866 Mr. Livingston Stone began the work of trout-culture at Charlestown, N. H., making his efforts successful after a short experience, and in 1872 he published a manual* on the culture of the trout, embodying the most detailed directions and the most complete compendium of the methods resulting from experience in trout-culture that has thus far appeared.

The results of Mr. Stone's experience have been made very valuable in his book, not so much by the devising of new methods and apparatus as by the scientific manner of his study of the questions and difficulties that present themselves to all culturists. His accounts of the ills and diseases that prevail with trout and eggs, whether the remedies advocated are in all cases efficacious or not, are of great importance as describing their causes and defining their symptoms and consequences, the first step to a discovery of remedies. The knowledge of their character, of course, affords in a great degree precision in experiment and effort for their remedy and prevention. The tonic effect of fresh earth placed in the troughs under certain circumstances is probably of efficient value and has been indorsed by other culturists.

The supposed discovery of parasitic animals in the confervoid growth on injured fishes was probably the observation of certain reproductive stages of the *Achlya prolifera*.

Mr. N. W. Clark, of Clarkston, Mich., began a trout-establishment in 1867, and continued it a few years with success, until his time and

*Domesticated Trout: how to breed and grow them, by Livingston Stone, A. M., deputy United States fish-commissioner, proprietor of Cold Spring Trout-Ponds, secretary of American Fish-Culturists' Association, and editor of fish-culturists' department in "New York Citizen." "Purpurisque salare stellatus tergora guttis."—Ausonius, Idyl Tenth. "Make assurance doubly sure."—Macbeth, Act IV, Scene 1. Boston, James R. Osgood & Co., 1872.

attention became entirely engrossed in the propagation of other fishes. By his active interest in the art of fish-culture, and continual contributions to the press of Michigan, as well as a widely-circulated pamphlet* on the subject, he created a wide-spread interest in Michigan that has been largely influential in bringing about the judicious and efficient action on the part of the State government for the multiplication of food-fishes.

In treating of the progress in trout-culture, only those culturists are here referred to who have made their experiences and discoveries available to all by publication, and only those publications have been mentioned that were written by those pratically engaged in the work of trout-culture, and whose writings and teachings were derived from original experience.

The summary of advances made by the application of the art of fish-culture to the brook-trout in the United States may be repeated as follows: (1.) The establishment and development of interest in the work. (2.) A practical knowledge of the methods employed in the art. (3.) Diagnosis of the diseases and ills incident to the artificial propagation of fishes and the suggestion as to prevention and remedies for some of them.

The salmon.—Previous to the autumn of 1866 the efforts in fish-culture in America had been entirely in the direction of extending a luxury, as the brook-trout is properly considered in this light, its qualities, as before enumerated, adapting it rather to the appreciation and enjoyment of the fortunate few, than constituting an extensive food resource for the good of a large population. In this year, however, the attention of the Canadian provinces and the New England States became concentrated upon the salmon (*Salmo salar*) as there were the most apparent evidences of its decrease and of its probable extermination at no distant time in the streams where it formerly abounded.

At the period mentioned the propagation of the salmon was commenced in Canada on a thorough basis, a small building erected, and arrangements made for hatching out the eggs. Mr. Samuel Wilmot, of Newcastle, Canada, on Lake Ontario, undertook the direction of the work. He obtained fifteen mature salmon, but was deprived of eleven of them by the act of a band of marauders who feared that his presence on the stream would prevent their killing the salmon, contrary to the laws reserving and protecting them in the stream for spawning purposes. He was able to obtain and impregnate about 15,000 ova, of which a large proportion was hatched the following spring.

The next year a somewhat larger number was obtained and hatched, with moderate success, and some of the smolts from the preceding year found.

* Pisciculture, or Fish-Farming: an address before the legislature of Michigan on the artificial propagation of fish and the restocking of public waters of the State, delivered at Lansing, February 28, 1871, by Hon. N. W. Clark, of Clarkston, Mich. Detroit, 1871.

In 1868 a hatching-house of larger dimensions was built, and the experiment of using stream or surface water attempted, the hatching-establishments of America, with scarcely an exception, using water directly from springs. Mr. Wilmot's experiences have proved the entire success of stream-waters. He has continued to hatch large numbers of salmon from year to year, and has succeeded in amply stocking the streams of his vicinity.

He is quite confirmed in the belief that the salmon of the tributaries of Lake Ontario never go to the sea to spawn, but make the depths of Lake Ontario their home when they are not in the spawning streams.

For a few years he sold quantities of spawn to commissioners of fisheries and private citizens of several States; but the successes of this industry within our borders soon stopped the demand for imported ova.

In the year 1871 Mr. Wilmot made the experiment of planting a few thousands of young salmon in the waters of Lake Simcoe, tributary to Georgian Bay and Lake Huron, believing they would adapt themselves to these bodies of fresh water. During the same year he imported a number of the charr (*Salmo umbla*) from the breeding establishment at Keswick, England, receiving fifty of them in good condition, and placed them in the waters of his vicinity.

In the fall of 1866, when the salmon operations were begun in Canada, the commissioners of fisheries of the State of New Hampshire* made the initiative movement for the restoration of salmon by sending Dr. W. W. Fletcher, of Concord, to the Miramichi River, New Brunswick, to obtain salmon ova for the benefit of the Merrimack River.

He returned with about 20,000 eggs, a few of which were hatched in a spring near Concord, and the remainder placed in artificially-prepared beds in the bed of the river, where their development could be observed, and it was estimated that 90 per cent. of them hatched. In the following season the parrs were frequently seen.

The attempts at procuring eggs in New Brunswick were continued by Dr. Fletcher in 1867, and by Mr. Livingston Stone, of Charlestown, N. H., in 1868. The latter gentleman was sent under the patronage of the States of New Hampshire and Massachusetts, and established a hatching-house on the Miramichi in company with Mr. Joseph Goodfellow, of Newcastle, N. B., and under a permit from the Canadian department of marine and fisheries, on condition that half of the young fry produced should be returned to the streams of New Brunswick.

Through delay in receiving the official sanction of the government they were prevented by the local authorities from taking salmon, it being the close season on the river. This, however, came in time for obtaining nearly a half million of eggs, about one-half of which were transported to the United States, and distributed to hatching-houses in New Hampshire, Massachusetts, Connecticut, and New York.

From 1869 until 1872 salmon ova were purchased by the New England States from New Brunswick culturists, and from Mr. Wilmot, and in 1871

* For a full history of salmon culture in the United States, see page 226.

the attempt at obtaining eggs from salmon within the boundaries of the United States was begun* by Mr. Atkins, of Bucksport, Me.

The method adopted by him for procuring seed-fishes is by far the most efficient and certain of large results of any in use. The salmon, during the whole season prior to spawning, are obtained from the nets of the fishermen by purchase, and are moved by means of wells or live-boxes to the ponds prepared for their reception, where they are retained until the ova are ripe. By taking advantage of their instinct for seeking suitable spawning places they are at this time enticed into raceways, where they are easily taken by the operators, and the spawn and milt expressed, when they are returned alive to the ponds. Several experiments were made to discover what character of water was required to preserve salmon in good, healthy condition while confined in the ponds. The conditions of temperature below a maximum of 73°, or the depth above a minimum of four feet, did not seem to affect them as much as the penetration of light into the body of water, as the experiments made in water darkened from the coloring properties of vegetation through which it ran were more successful than in very clear water, even where the depth was slightly increased and the temperature much lower.

During his first year's experiments Mr. Atkins employed the dry method of fecundation, which had been brought to the notice of American fish-culturists by the translation from the *Bulletin de la Société d'Acclimatation*, August, 1871, of the observations of Vladimir Pavlovitche Vrasski in 1856. By reference to the essay on fish culture, by Carl Vogt, the embryologist, of Geneva, Switzerland, of which an abridged translation was published by George P. Marsh in 1857,† it will be seen that Vrasski was anticipated by him in the announcement at least, if not the discovery of this method.‡

In describing the process of artificial impregnation, Vogt says: "The eggs and milt should be received in a shallow vessel containing barely

* See page 233.

† Report on the Artificial Propagation of Fish, by George P. Marsh, Burlington, Vt., 1857.

‡ The studies of the embryologists from the time of Von Baer discovered the fact that the spermatozoa of many animals retained the power of movement for a long time while subjected to a microscopic examination. In fact, Von Baer believed them to have a separate, independent life from the animal to which they belonged. This view was confirmed by others, and it was carried so far as to regard them as possibly infusoria, and as in their habit entozoic or parasitic, within the organs of animals. The fact of their independent life was first disputed by Treviranus, who believed their movement to possess no voluntary character, and that in their structure and properties they were analogous to fibrils and particles in the pollen of plants. The later physiologists are inclined to accept the latter view, so that their possession of life is as a part of the animal from which they are thrown off. They have a capacity for sustaining vitality for a time after separation, somewhat as the blood-corpuscles do in the operation of transfusion, or as in epithelial cells. They thus become the medium for the transmission of a portion of the life of the male to the egg of the female, which previously is inert.

water enough to cover the eggs expected to be obtained, and a little experience will enable the operator to estimate the quantity accurately enough. An excess of water is injurious because it dilutes the milt, disperses the seminal animalcules, and diminishes the chances of impregnation." On another page he says: "Since, then, the egg completes its absorption rapidly, and the currents attracted by it very soon cease, and since the seminal animalcules speedily lose their vitality in water, it is a matter of great practical importance to perform the processes for facilitating impregnation with as little loss of time as possible. The best method is doubtless to mix the milt with water and then immediately drop the spawn into the mixture, as the attraction arising from the absorption of water by the egg serves to direct and facilicate the movement of the animalcule toward the orifice, and this conclusion is abundantly established by observation."

It has been stated that Seth Green early applied these principles in fecundating eggs, and it is regarded as largely the secret of his success. If so, however, he kept his method a profound secret, not exercising it in public, or making any reference to it in his work.

In 1872 Mr. Wilmot, in his report* to the Department, asserts that experience taught him each year to use less and less water, and, finally by experiment, that his greatest results were attained without water, and in 1872 he adopted the system of dry impregnation.

The American system of dry impregnation, which from present record would seem to have been originated by Mr. Atkins† in 1871, differed from that of Vogt and of Vrasski, inasmuch as he did not dilute the milt or allow water to come in contact with eggs or milt until a full application of pure milt had been made. The contact was secured by moving the eggs rapidly in a pan, the milt and eggs being thus thoroughly mixed, after which water was poured into the mixture.

In the fall of 1872 Mr. H. F. Dousman, of Waterville, Wis., extensively engaged in trout-culture, applied the dry method of fecundation and frequently with this modification, that, instead of obtaining contact of eggs and milt by stirring them together, he trusted entirely to the persistent impulses of the spermatozoa to move directly forward, and covering the bottom of a pan with ripe trout-eggs, applied the milt in several spots, when, after a few minutes, it could be detected by its milky appearance to have diffused itself among all the eggs.

Mr. Livingston Stone, in his operations in California in 1872, while procuring spawn of the Sacramento salmon, (*Salmo quinnat,*) continued putting eggs into the impregnating pans until they were half filled before he applied the milt, and then stirred them with his hand until thoroughly mixed before he poured in water. He succeeded by this method in impregnating nearly 100 per centum of the eggs.‡

* Annual Report of the Department of Marine and Fisheries (Canada) for the year ending 30th June, 1872. Appendices of the Fisheries Branch of Department Marine and Fisheries, p. 96.

† See page 239.

‡ See page 173.

The experience of all indicates that the continuation of vital functions after removal from the living fishes or while retained in the body after death, is retained much longer by the eggs than by the milt. When in Mr. Atkins's experiments they were taken at the same time, it was found that the eggs could be fertilized with fresh milt long after the stale milt had lost all power. The series of experiments in different methods of fecundation by Mr. Charles G. Atkins* prove the dry method to be much superior in its results to the use of water at the time of expressing eggs and milt. This seems to be the uniform testimony of all who have tested it.

The apparatus used by Mr. Atkins, in 1871, was the ordinary trough, but instead of covering the bottom with gravel, upon which to place the eggs, he arranged strips of glass transversely in frames, which were set all along the length of the trough, and about an inch above the bottom. Upon these the eggs were placed, arranging themselves in parallel rows, and having a free circulation of water on all sides.

In 1872 a large building was erected,† troughs put in, and wire-cloth screens or trays, on light wooden frames arranged about five-eighths of an inch from the bottom, were fitted to the troughs. These devices were improvements, though not the first in use,‡ upon the ordinary graveled troughs.

The breeding establishments in different parts of the country received the salmon-eggs from places where they were procured and partially developed, and in this way they were distributed over a considerable extent of country, the most extensive distribution being made in 1872, under the direction of the United States Commissioner of Fisheries.

In the first experiences of the culturists having the salmon in charge, the young were retained for several weeks and even months after the yolk-sac was absorbed, in many cases a heavy per cent. of losses occurring during the time. A general conclusion was arrived at that it was better to turn them loose much earlier, and this has become the usual custom.

In 1872 the operations for procuring the eggs of the salmon of the Sacramento River were begun by the United States Commission of Fisheries, Mr. Livingston Stone being deputized for this work. The principal results of his experiences benefiting the art of fish-culture were the method of impregnating eggs in considerable masses and freeing them from the growth of conferva by washing them in a mixture of sand and water. Mr. Stone attributes the origin of this suggestion to Mr. Woodbury, a fish-culturist of California, whom he had employed to assist him.

The transportation of the impregnated eggs eastward, and planting the young fishes in the eastern rivers in large quantities, which has been undertaken by the United States Commission of Fisheries, is an

* See pp. 259 and 282. † See note, p. 247. ‡ Referred to on a subsequent page.

extensive and novel work compared with all previous enterprises in fish-culture; and as far as the rivers of the Atlantic coast southward from the Connecticut are concerned, salmon will experience no change in conditions that will prevent a successful result, except possibly the great numbers of nets that may hinder the ascent of the salmon in the rivers at the spawning-season.

A summary of the very important results that have been developed in the culture of salmon, enhancing the interest of fish-culture, would begin with—

(1.) The official attention of States to the restoration of inland fisheries by artificial propagation, which began in Massachusetts in 1856, but took practical shape in 1866, when Dr. W. W. Fletcher, of Concord, was sent by the State of New Hampshire to obtain salmon-eggs from the Miramichi River of New Brunswick. In the same year the government of Canada began a like enterprise, and in Canada and the United States it has been continued and become a successful and more and more extensive enterprise yearly; and since 1872, under the auspices of the United States Commission of Fisheries, an extensive distribution of this valuable species has been carried out.

(2.) In the culture of this species by the Canadian government and the State of New Hampshire, the first application in America of the artificial propagation to a commercial fish of wide demand and extensive sale in the market was instituted.

(3.) An improved method in impregnating, resulting in the fertilization of almost the entire quantity of eggs, and that is essentially an American method; as in the so-called dry method in Europe, in all instances it is provided that water should be used, though in small quantity, while the method first used by Mr. Atkins, and afterward by many fish-culturists of the country, makes no application of water until after the eggs and milt have come thoroughly into contact.

(4.) Mr. Atkins's manner of obtaining seed-fishes by purchase through the whole of the period of immigration into the rivers prior to spawning and preserving them in ponds, is an original method for obtaining an unlimited quantity of eggs, not, I believe, before adopted in any country. In Switzerland living salmon have been transferred to new locations for natural spawning, or those about to spawn have been transferred for a short time to ponds, and the eggs taken; but as far as we can learn, Mr. Atkins was the first, at least on a large scale, to secure salmon in the spring, on their entrance into the river, and keep them for four or six months.

(5.) The arrangement by Mr. Atkins of troughs having trays placed at a distance above the bottom was a decided advance in apparatus, from the facilities afforded in manipulation of the eggs and removal of sediment.

The shad.—In 1867, it was determined by the commissioners of some of the New England States to attempt the restoration of the shad by

artificial propagation, and the aid of Seth Green was obtained in the matter. He began his experiments at South Hadley Falls, on the Connecticut River, using the ordinary methods and apparatus in trout-hatching, which failed entirely to answer the purpose, because of the low specific gravity of the eggs and the coldness of the water used.

He then attempted to hatch them in floating boxes with wire-cloth bottoms, which proved for a long time failures, because of the difficulty of producing a current inside of the boxes that would keep the eggs in motion, until happily he tried the experiment with a box having the bottom tilted at an inclination toward the current, when he found the eggs were gently and continuously stirred by the entering waters, and the proper construction of apparatus indicated.

The quantities of young shad released into the river made a considerable impression on the fisheries three years afterward.

This seems to have been the first attempt to artificially fecundate and hatch the eggs of any species of this family, (*Clupeidæ*,) which contains species affording a very large proportion of the resources represented among the commercial food-fishes of the world, including the Astrachan herring of Russia, shad, alewife, herring, sardine, anchovy, menhaden, sprat, &c. The three first named are anadromous, and for these only, in the present state of fish-culture, will the art be available.

There has been no instance in the history of fish-culture where its application to the restoration of a species has so quickly and certainly afforded evident results as in the experiments of Seth Green upon the shad of the Connecticut River. Mr. Green continued his work the succeeding year, using the same model of box, which has not been improved upon since, though experiments with other models have been made by other fish-culturists on the Merrimac and Androscoggin Rivers. In 1869 he began on the Hudson River, under the auspices of the State commission, and a yearly increase of the species has resulted.

In 1871 he successfully moved a quantity of shad to the Sacramento River, California, and in 1873 the United States commission transferred a large number to the same river. A few have since been taken in the river, and the State commissioner thinks that others have been captured, and the fact concealed, on account of the penalty imposed upon any one taking them during five years after their first planting in the Sacramento.

The New York commissioners have had considerable numbers put into the Genesee River of Lake Ontario, and an extensive distribution into the tributaries of the Ohio and Mississippi Rivers and great lakes has been carried out by the United States.

The hatching of shad is prosecuted each year by Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, and by the United States commission. Full references to these State and national operations will be found elsewhere in the present report.

The progress in the history of fish-culture in the United States resulting from its application to the shad may be summed up as—

(1.) The foundation of a hatching-establishment by a State. Though a permanent building or even location is not an accessory of shad-hatching, still, the ownership of apparatus and the continuance of its use from year tc year in the waters of a State are very properly to be considered as the founding of a hatching-establishment, and in this Massachusetts took the lead in 1867.

(2.) The shad-box invented by Seth Green was an advance of very great consequence, not only because it made it possible to increase the shad, its most important result thus far; but because it is adapted to, and in fact suggested the possibility of hatching the striped bass, and it was also found by Mr. Stone to be quite convenient in bringing forward the eggs of the California salmon when his hatching-house was found to be filled and plenty of eggs still to be obtained.

(3.) In the fact that young shad are delicate and with difficulty kept alive during transportation, the large amount of experience that has been brought to bear in their extensive distribution has led to improvement in method and in a more explicit knowledge of the needs and requirements of young fishes during transportation.

The white fish.—In November of 1857 Mr. Carl Muller, of New York, and Mr. Henry Brown, of New Haven, (see page 534,) having received from the State of Connecticut certain protective interests in Saltonstall Lake, near the city of New Haven, began a system of operations for stocking it with fishes, and the wall-eyed pike of the Ohio, the salmon-trout, and the white-fish of Lake Ontario were all transferred to the waters of the lake by means of eggs procured and impregnated artificially.

The account of the operation indicates a rather crude knowledge and method in the art of fish-culture, and it is probable that why a small proportion of eggs was hatched. The estimates of the number of eggs are very large. They were packed in moist sand and placed in the bed of the stream on their arrival, the white-fish eggs on a sandy shoal of less than three feet depth. The presence of young fish in great numbers in the following March and April was believed to result from the eggs, though the exceedingly common error on the great lakes of mistaking the schools of small cyprinoids for young white fish, which they very much resemble, except in the absence of the adipose dorsal, may have been repeated here.

In the fall of 1858 the experiment was renewed. There has been no reference made to any permanent results from this experiment in the reports of the State commissioners.

A more successful series of tests were begun in 1868 by Seth Green and Samuel Wilmot in applying artificial culture to this species, and in the succeeding year by Mr. N. W. Clark, of Clarkston, Mich. They were found to be very delicate and difficult to hatch in the first few

years of experimenting, but methods were perfected that made their production as certain and with losses nearly as small as in other species.

The necessity of production of immense numbers in attempting to multiply the market species of fishes established the fact that the apparatus used in trout-hatching had to be extended over a wide area to accommodate them. The culture of the white fish and the salmon-trout induced modifications of apparatus at the New York State hatching establishment.

In 1872 wire-cloth trays were introduced within the troughs, placed one above another, four in depth. These trays were made of double lath on the sides and single on the ends, so that the current in the troughs passed through the narrow spaces at the ends, washing both the upper and lower sides of the wire-cloth on which the eggs were placed. A large supply of water was afforded each trough. The ordinary bed of gravel remained at the bottom of the troughs, in which the young fish were allowed to rest and hide themselves during the greater part of the yolk-sac period.

This apparatus was in some respects superior to that of C. G. Atkins, in the fact that it not only afforded facilities in manipulating the eggs, but afforded economy of space.

In 1872, at the New York State hatching-house, a new device was invented (perfected in 1873) by Marcellus G. Holton, of Seth Green's staff, to obviate the defects of the ordinary graveled troughs, and even of the improved trough. The arrangement of wire-cloth trays within troughs afforded a ready manipulation of the eggs, and a better opportunity for removing sediment and the omnipresent confervoid growth, (*Achlya prolifera*,) but did not afford in a sufficient degree the great desideratum of economy of space.

This apparatus (see plate) consisted of an outside case or box of wood, with a pipe conducted from a reservoir of water into the bottom, and the top of the case being below the source of supply, the water, of course, filled and overflowed at the top; within this case a series of wire-cloth trays were fitted, placed one above the other, from seven to eighteen in a case; and in the largest size not more than eighteen inches square, and containing about 18,000 white-fish eggs to the tray, so that in a space about 4 feet in width by 8 feet in length, 2,000,000 of white fish may be hatched, while at the very least twenty-five of the ordinary graveled troughs would be required for this number of eggs, filling the space of a very large hatching-house.

In 1873 a device to accomplish like results was made by Mr. N. W. Clark, of Clarkston, Mich., and patented in 1874. (See plate.)

This arrangement employed the troughs, but divided them into compartments by means of water-tight partitions or bulkheads; into each compartment a box containing a series of trays filled with eggs is placed and covered with a pan of perforated tin, upon which the water falls and descends through the perforations upon the screens and eggs be-

neath, passing through all and escaping at the bottom, afterward flowing over the partition upon the cover of the next box, and so throughout the series of compartments until it escapes through the waste-way at the end of the trough.*

By this arrangement a very small quantity of water is required for a very large number of eggs, and all the advantages of handling and removal of sediment and considerable economy of space are afforded.

Another combination of the trough and tray methods is in use in California, devised by Mr. John Williamson, of the California Acclimatizing Society. This is very similar to the one just described, except that the flow of water through the screens and eggs is from below instead of from the top. This model was not the result of work in white-fish hatching, as in the case with the two first mentioned.

An experiment was made by Mr. N. W. Clark in the hatching of white-fish eggs, which were laid in singlelayers of woolen cloth stretched on very thin frames of wood, packed in a box imbedded in sphagnum moss within a refrigerator and the whole kept at a temperature a little above the freezing-point by ice. The eggs are left entirely undisturbed after they are first arranged, and the only care on the part of the attendant is to keep the temperature above the freezing-point. The presence of dead eggs does not seem to contaminate the living ones in this condition, and very little confervoid growth appears. A quantity of eggs carried forward in this manner through the winter appeared to be in excellent condition, development progressing slowly, and a few taken from the cloths and placed in spring-water hatched out within a short time as well-developed embryos. If this method, after full and thorough trial, should prove successful, it would make the work of hatching a matter of neither effort, care, or expense. It has been a matter of too short experience and of experiment on too small a scale to warrant its positive success.

An improved case for the carriage of eggs long distances by railroad is another device perfected by Mr. N. W. Clark in 1872. It is a modification of the ordinary case containing circular cups, the cups being square, and in this form economizing space very much. The cups of tinned iron, about four inches square and two inches high, rest in trays, with low partitions forming low compartments that retain the bottom of each cup and hold it solidly in place. The trays are set within a square tin box, in which they fit with moderate tightness, and are placed, when containing the cups, eight or ten in the box, one above the other; this box is set within another box of tin large enough to leave an open space on all sides, to be filled with sawdust; a tube is inserted through the bottom of the inner box, piercing the bottom of the outer one, so as to permit communication with the air on the outside; the whole is then placed for protection within a strong wooden box, in the bottom of which is a frame resting upon stiff springs which relieve the

* For full description see plate and explanation.

eggs from heavy jarring; rubber or cloth bumpers on the sides of the box prevent lateral swaying and jolting. A cover is fitted to the inner box, which may then be covered with sawdust to the level of the higher outer one, when the cover of this is to be shut down. The outside wooden box is fitted with handles and with a tight lid on hinges, which may be locked. Small auger-holes are bored through the outer or packing box and air may be admitted to the whole interior of the egg-case through the tube referred to in the bottom, the cups being pierced with small holes, so that when in place they are directly over circular openings in the trays and a communication of air is established throughout.

The eggs may be packed in moss, in the ordinary manner, in the cups which experience seems to prove to be the best manner for long journeys.

The method of Mr. Atkins in shipping salmon-eggs packed in moss, but with pieces of mosquito-netting laid above and below the eggs, is a great convenience in unpacking them, and could just as well be applied in the cups. This, though less simple than the ordinary egg-carrier, is sufficiently simple for practical purposes, and possesses most important advantages for carrying eggs long distances and over rough roads, the small area of surface within the boxes preventing any tendency of the eggs to slide together at one side; the square boxes resting in trays are put together in much more compact form than the cylindrical boxes embedded in moss, and the springs beneath the boxes of eggs are of course an important addition.

Mr. Clark believes the hatching-apparatus in the refrigerator to be as well adapted for the carriage of eggs as for hatching them.

The use of surface or brook water in any permanent establishment seems to have been first employed by Mr. Samuel Wilmot, of New Castle, Canada, the greater number of hatching establishments using spring-water.

In the hatching of white-fish, Mr. Clark has contended for the use of brook-water in preference, because of its lower and evener temperature throughout the winter, and the consequent retardation of the hatching of the fish which he has contended is an essential provision in nature to their welfare, and that the hatching them two months or more previous to the natural time under artificial conditions is a mistaken method that will not result in the maturing of any considerable numbers of the cold waters in which they are released. Though this view has not been established by practical observation, yet it raises a question of considerable importance that merits a full discussion of its character and bearing on the practical work of fish-culture. A few extracts from a letter of Mr. Clark to the board of fish-commissioners of the State of Michigan, will advance his arguments in favor of brook or surface waters in preference to spring-water. Mr. Clark began his experiments with white-fish in 1869, hatching a small percentage of the eggs he procured:

"In November, 1870, I started again for Ecorse for the purpose of procuring more spawn. Mr. George Clark, at his fishery, very kindly rendered me all the aid in his power, furnishing the parent fish for the purpose of trying further experiments in this new enterprise. I succeeded in obtaining all the spawn needed for further trial, but he was so anxious to make it a success that he sent his man to me with an extra lot which he thought might be in better condition. I succeeded in hatching a much larger proportion of them than the year before, but raising them with artificial food was attended with no better success. This second effort and failure led me to investigate the cause, and after much thought I came to the conclusion that if we ever succeeded in making this branch of pisciculture a success, we must study the principles of nature more than had ever been done before. I became fully satisfied that by arranging so as to use water taken from a pond or lake entirely frozen over, it would retard the development of the eggs to the time required by nature, which proved by subsequent experience to be about April 1. I then consulted Messrs. George Clark and John P. Clark, and made known to them my convictions, and so strongly were they convinced that I had struck the key-note to insure ultimate success that they proposed to furnish all the necessary materials and a portion of the labor to enable me to go on and erect a large hatching establishment. This was located about 80 rods below the spring where we had been experimenting the two years previous with the unsatisfactory results above stated. This location was supposed to be a sufficient distance below the main spring, so that by damming the water and raising a pond it would freeze over and remain so during the period of incubation.

"Our views proved to be correct, as the 500,000 of eggs which we placed in the hatching-boxes November 15 of that year were preserved in fair condition, and with one-quarter less labor in caring for them than formerly. They did not commence to hatch until April 1, and it was estimated that we succeeded in hatching at least 50 per cent. of the eggs we had taken four and one-half months previously at the fishery of George Clark.

"Of these young fry, some 100,000 of them were put in Detroit River, at or near his fishery place, and no doubt at this time they are thriving finely in the waters of Lake Erie, which abounds with abundant natural food for them, and in a year or two more they will doubtless return to the same place where they were deposited. The balance of them we placed in three small lakes in Oakland County, some of which have been seen within the last few months, doing finely.

"This experiment proved so great a success that again, the next November, 1872, through the encouragement of the Messrs. Clark and the United States Fish, commissioner, I doubled the capacity of this hatching-house and procured 1,000,000 of the ova from the same grounds, and proceeded as before with some improvements I made in the *modus operandi* of

hatching about February 20. Mr. Milner, deputy United States commissioner, arrived at this place for the purpose of aiding me in packing and shipping a lot of the ova, which were then in an advanced stage of incubation. We estimated from actual count that 66 per cent. were in such an advanced state that they were secure from any further mortality. We then shipped to San Francisco 216,000 in the most perfect condition.

"About March 10 I received an order from the commissioner at Washington to send the same number again to the same place, which I should have done, but from the fact that the eggs had become so far advanced that I felt quite confident they could not be transported so great a distance successfully, and only sent 116,000, which I am most happy to have heard arrived in excellent condition. Soon after this the weather became much warmer and the ice all thawed from the pond, and by the 20th of the month the eggs then remaining in the troughs commenced hatching. The water had then risen to a temperature of 45 degrees, which sudden change caused the eggs to turn white, and soon all were worthless. Quite a large number had already hatched out, and I removed part of them to the same lake where Mr. George Clark and myself had put in a large number the year before, and placed about 25,000 in a small lake at Clarkston Village.

"This sudden change in the condition of these eggs I cannot account for, only from the fact of the change in the temperature of the water at this late stage of their development. I am fully satisfied that if the ice had remained in the pond as late as the previous year I should not have lost two per cent. from the time I made the last San Francisco shipment.

"This experience satisfied me that spring-water, although it may not be used until it advances a long way down from its source, is not the place to hatch white-fish. Although this pond was clear from ice March 15, the ice remained in our lakes in this region until May 1.

"This species of eggs, and especially those not good and not perfectly impregnated, placed in spring-water at a temperature of 46 degrees (which is about the same as all good springs) in winter, will start out a growth of vegetable fungi more than four times faster than if placed in water at 33 degrees, which is the temperature of ice-water, and it is next to impossible to employ help enough to pick out the dead eggs (when in spring-water) when you have over a million, as I had the last two seasons.

"Even in ice-water last winter, which preserved the eggs much longer than in spring-water, it required from eight to ten persons to keep them in fair condition, and then sometimes they were necessarily left too long in an unfavorable condition.

"These facts are conclusive proof to my mind that the ova of white-fish should be kept entirely away from the influence of spring-water, or any water which will be liable to change during incubation, and all

houses where white fish are to be hatched should be constructed upon some lake or pond that freezes over early and does not thaw out until April 1.

"It is stated as a reason why spring water is better for hatching fish eggs than lake water, that it is generally more free from sediment, some kinds of which are highly detrimental to the successful hatching of the fish ova. Whereas our inland lakes freeze over early in the fall, and are not free from ice until late in the spring. This ice is perfect protection against any agitation of the water, and gives an opportunity for any sediment that may be in it to settle to the bottom, where it must remain until spring, and until the eggs are hatched and distributed. Consequently the water in all of our inland lakes is, during winter, as clear as crystal.

"You also wish me to give my views in reference to using Detroit River water. To this I will frankly say that I should much prefer it to any spring water in this or any other State for hatching white fish. But there are some objections which arise in my mind even to this water. I am aware that this species of fish are natives of our great lakes and rivers, and consequently it would be supposed that this water must agree with them, and that success would be certain if this water was used. But has it not occurred to all persons who have given this subject much thought that much the largest proportion of these fish run to the shoals of those lakes during spawning season to deposit their ova? These shoals are the first to freeze over in the fall and the last to thaw in the spring. This keeps at nearly the same temperature during incubation. Although it may be said that during their migration from Lake Erie to Lake Saint Clair some deposit their spawn in the rivers; it is not very probable that much of it is hatched.

"I am aware that many hatch in and about the ponds where the fishermen preserve their fish for winter use. This tends to prove that the shoals are the place where they hatch most largely, as the ice remains in these ponds much longer in the spring than in the strong current in Detroit River.

"If water is used from this river it must change in temperature many times during the winter, as it is well known that the ice leaves the river quite often during the four-and-a-half months of the period of incubation. No one can gainsay the fact that in the hatching of fish ova, if the water is of a perfectly even temperature, it will be attended with more favorable results than when frequently changing, from any cause, even if such change is not more than two or three degrees. Is it not also a fact that the ice frequently leaves the lower part of Lake Saint Clair early in March? If so, would not the westerly winds roll the water in the upper part of the river? This sediment would be deposited on the eggs, and in consequence of its fine, clammy nature, would be injurious to them. I noticed this was the case in a little experimental arrangement of A. M. Campau, some two years since, where this water

was used. I examined these eggs several times during this process, and found a fine, clammy substance accumulating on them. They were gradually dying, and I do not think any were hatched. These eggs were taken from our hatching-boxes, and were in perfect condition, as they were so far advanced in development that the embryo fish could be plainly seen with the naked eye. For these reasons I am forced to the conclusion that there is more suitable water for hatching this species of fish-eggs than the Detroit River.

"I wish, however, to have it distinctly understood that salmon, salmon-trout, and brook-trout should be incubated in pure spring-water, as they will hatch the latter part of January or early in February. They have an umbilical sack from which they derive their subsistence, and which takes about fifty days to absorb. They do not require food during this period. After this, by feeding them a few days, they will do to turn loose in water adapted to them, where they will find their own food. For these reasons it would be very desirable if your commission could find a location where both spring and lake water could be supplied in sufficient quantities to insure the success of breeding both kinds.

"Most respectfully and truly yours,

"N. W. CLARKE.

"*Clarkston, September* 13, 1873."

In conclusion, the advantages afforded American fish-culture from the cultivation of the white-fish as they have just been enumerated: These are; (1) more careful and perfect methods, resulting from the experience in the culture of the most delicate and difficult species whose propagation has been attempted by culturists; (2) the perfection of three forms of apparatus for hatching fish eggs, embodying the important improvements of facility in handling the eggs and removing sediment and confervæ, and greatly economizing space; (3) the contrivance of a superior case for the carriage of eggs; and, besides, a possibly successful, entirely new method in the hatching of eggs and the discussion of and practical tests of conditions of water suitable to the eggs of a species that we are not (at any rate thus far) able to supply with food.

The Otsego bass.—Another species (?) of white-fish (*Coregonus otsego*) has been successfully propagated at Cooperstown, N. Y. A large quantity of eggs were impregnated in the autumn of 1871, and in the following March several thousands of young fishes were set free in the lake. In 1873 a larger number were released, and a quantity of eggs put into the hatching-troughs.

The salmon-trout.—In the fall of 1857 and 1858 a large number of eggs of salmon-trout were obtained for Saltonstall Lake in Connecticut from Lake Ontario. The enterprise is referred to more fully on page 534.

A minor experiment in hatching salmon-trout, or Mackinaw trout, (*Salmo namaycush,*) was made by Mr. Samuel Wilmot, of Newcastle, Canada, in 1868. He also obtained a hybrid between a male *Salmo salar* and a female *S. namaycush.* The next published records we have of ex-

periments are by Seth Green and by N. W. Clark in 1870. Mr. Clark's was with but a few eggs. In an address before the legislature of Michigan, he refers to the fact of having young salmon-trout on exhibition.*

The quantity of eggs taken by Seth Green that year and hatched was very large; and the fish proving to be a great favorite among the people of the State, he has continued to breed it on a large scale, and it has been widely distributed throughout the State.

The greatest drawback in the culture of this species is the difficulty and danger attending the procuring of the eggs.

The spawning-places of the fish in the region of the hatching-houses is in the open lake; and the time when the ova are ripe is in October, when there are frequent storms, so that going out in an open boat to the nets is a task of hardship and danger, and has resulted, in a late instance, in the loss of six men, one of them Marcellus Holton, an accomplished fish-culturist and the inventor of the Holton hatching-box. There are however, points on the lakes accessible by steamer, though not contiguous to the breeding-establishments, where the salmon-trout spawning-grounds are near the shore, and even entirely land-locked from wind and sea.

The striped bass.—In connection with the work of the United States Commission of Fisheries, a successful experiment has been made which bids fair to be one of great importance in connection with the history of fish-culture. In 1873, Mr. Marcellus Holton, one of the men who were lost while obtaining the spawn of the salmon-trout on Lake Ontario, was employed by the United States Commissioner in the work of shad propagation on the Roanoke River, North Carolina. While at the fisheries near Weldon, he procured and impregnated the spawn of the rock-fish, (*Roccus lineatus*,) and succeeded in hatching then. The appended letter gives his method and the extent of his success:

"WELDON, *May* 22, 1873.

"DEAR SIR: I think, from indications observed, that the rock-fish spawn in the day-time. We find the eggs are much lighter and more delicate than those of the shad. We have afforded them similar treatment, using the shad-boxes, and I think it is evident that they hatch a little sooner, but do not feel sure on this point, as I was obliged to move the boxes, while containing the eggs, below the falls, and the water was very rough while passing the rapids. I was compelled to move them because of the rapid rising of the river, which threatened to flood us out on the low shore, where we were encamped. It is quite possible that this hatched them prematurely. In twenty hours after impregnation, and before they were exposed to the rough water, the fish within the egg showed signs of life, and in forty hours kicked lively.

* Pisciculture, or Fish-Farming: an address before the legislature of Michigan, &c. Delivered at Lansing, February 28, 1871, by Hon. N. W. Clark, of Clarkston, Mich. Detroit, 1871. Page 21.

"They escape through the meshes of the wire-cloth as fast as they hatch. It will take at least twenty-four wires to the inch to hold them, and I think the eggs require less current than shad-spawn.

"Yours,

MARCELLUS G. HOLTON.

"Prof. SPENCER F. BAIRD,
" *Washington, D. C.*"

Mr. Holton, in another letter, reported the eggs obtained from two spawners at 120,000, and out of these he estimated the number hatched at about 70 per cent., or 80,000 young fry. The female parents weighed six and eight pounds. The eggs were nearly equal in size to those of a shad; the newly-hatched fry were somewhat smaller.

The fact that the ova were non-adhesive, unlike most of the percoid fishes that have been dealt with, was a matter of surprise. The weight of the spawning-fish is somewhat less than has usually been attributed to rock-fish in spawning-condition. If localities can be found where rock-fish may be taken in sufficient numbers in the breeding season, the increase of this species is probably as sure to be effected as that of the shad has been.

We append a list of the species already referred to, and also of those with which small experiments have been made, with varying success, in the United States. The perch, (*Perca flavescens;*) the wall-eyed or glass-eyed pike, (*Stizostedium americanum;*) the rock-bass, (*Roccus lineatus;*) the salmon, (*Salmo salar;*) the California salmon, (*Salmo quinnat;*) the brook-trout, (*Salmo fontinalis;*) the Pacific coast brook-trout, (*Salmo iridea;*) the Utah trout, (*Salmo virginalis;*) the land-locked salmon, (*Salmo sebago;*) the salmon or Mackinaw trout, (*Salmo namaycush;*) the lake white-fish, (*Coregonus albus;*) the Otsego bass, (*Coregonus otsego;*) the lake-herring, (*Coregonus clupeiformis;*) the grayling, (*Thymallus tricolor;*) the shad, (*Alosa sapidissima;*) the alewife, (*Pomolobus pseudo-harengus;*) the common sucker, (*Catostomus communis;*) the shiner, (*Stilbe crysoleucus;*) the corporal or chub,(*Semotilus corporalis.*)

Collating from numerous authorities on fish-culture in Europe, we are enabled to give the following list: The burbot or *la lotte*, (*Lota vulgaris;*) the salmon, (*Salmo salar;*) the sea-trout, (*Salmo trutta;*) the river-trout, (*Salmo fario*); the lake-trout, (*Salmo lacustris;*) the *ombre chevalier* or *röthel*, (*Salmo umbla;*) the charr, (*Salmo alpinus;*) the hucho, (*Salmo hucho;*) the laveret, (*Coregonus laveratus;*) the fera, (*Coregonus fera;*) the maræna, (*Coregonus marœna;*) the *palée*, (*Coregonus palea;* the *Coregonus albula;*) the grayling, (*Thymallus vulgaris;*) the carp, (*Cyprinus carpio;*) the crucian carp, (*Cyprinus carassius; Cyprinus kolfarii;*) the tench, (*Tinca vulgaris;*) the white-bream, (*Abramis blicca;*) the ablette, (*Cyprinus alburnus;*) and the sterlst, (*Acipender ruthenus.*)

Of the hybrids claimed to have been produced artificially, which but few seem to have attained maturity, we give the following list:

EUROPEAN SPECIES.

Male.		Female.
The salmon, (*Salmo salar.*)	with	The river-trout, (*Salmo fario.*)
Do., do.	do.	The lake-trout, (*Salmo lacustris.*)
Do., do.	do.	The *ombre chevalier*, (*Salmo umbla.*)
(?) *Ombre chevalier*, (*Salmo umbla.*)	do.	The salmon, (*Salmo salar.*)
The river-trout, (*Salmo fario.*)	do.	Do., do.
Do., do.	do.	The *ombre chevalier*, (*Salmo umbla.*)
The *ombre chevalier*, (*Salmo umbla.*)	do.	The river-trout, (*Salmo fario.*)
The lake-trout, (*Salmo lacustris.*)	do.	The salmon, (*Salmo salar.*)

AMERICAN SPECIES.

The white-fish, (*Coregonus albus.*)	The salmon-trout, (*Salmo namaycush.*)
The alewife, (*Pomolobus pseudo-harengus.*)	The shad, (*Alosa sapidissima.*)

The advances made in the art of fish-culture by its adoption in this country are now extended by its application to a number of new species.

In the family of *Clupeidæ* nothing seems to have been attempted in Europe, while in America the culture of the shad (*Alosa sapidissima*) is one of the most extensive and successful efforts in fish-culture, and that of the alewife (*Pomolobus pseudo-harengus*) has been experimented upon with success.

In the genera of *Salmo*, *Coregonus*, and *Thymallus* there is entire similarity of condition between American and European species, though the species are different, except in the case of *Salmo salar*.

In apparatus there are several advances. Though in considering the shad-box (see plate) we find the floating-box with wire-gauze in use in the old world for years,* still its inclination to the current, in the manner of Seth Green's patent, is an improvement in producing a complete and continuous circulation of water.

The tray-methods of Holton, of Clark, and of Williamson (see plates) are of great importance in economy of space, in the facility for manipulation of the eggs, and, in saving of expense, because smaller buildings are sufficient for the accommodation of apparatus, and from the compactness of the apparatus more labor can be accomplished than with the extended trough method.

Improvements in egg-carriers and in vessels for transporting young fishes have been referred to on another page.

The advance made in methods of impregnation and care of ova are the results of continued experience and study. The so-called dry

* See Vogt's Essay on Fish-Culture. Translation in Report on the Artificial Propagation of Fish, by G. P. Marsh, Burlington, Vt. Page 41.

method of impregnating ova in Europe and the more properly dry method of America are the most essential improvements, as they have increased the results from a given number of ova in a large ratio.

It will be observed that advances have been made both in apparatus and in methods by the extension of the application of the art to new species of fishes. Seth Green's shad-box was the result of the experiment in hatching shad. The tray-methods of Holton and of Clark were the result of attempts in hatching the lake white-fish, a species that at first gave discouraging results to the efforts of those who attempted it. An improved knowledge and system for transporting live fishes resulted from the distribution of shad; a species that was found to be exceedingly delicate, and requiring great care in transportation.

The American system of dry impregnation was discovered in the salmon-breeding establishment of C. G. Atkins. Different conditions and necessities arise in the experiments with each species, and new ideas more or less applicable to other species are developed.

The application of fish-culture to species having adhesive eggs has scarcely begun in this country; a few experiments with the glass-eyed pike, the perch, and with a species of the smelt are all that have been recorded. Experiments with one of the sucker-family, *Calastomidæ*, and with a cyprinoid, are referred to without stating the character of the eggs, which were probably adhesive. The eggs of the ale wife have proved adhesive for a considerable time during and after impregnation, but are not to be included in permanently adhesive eggs.

In Europe there has been a great deal done with this group of fishes; the carp, of several species and varieties, engaging a great deal of attention.

The value of this fish as an accession to the number of food-fishes of the United States is a matter of importance. The estimates of their qualities as table-fishes are very varying and contradictory.

Those who are familiar with the food-fishes of the fresh waters throughout Europe assert that this arises from the difference in quality of different varieties and species; and that while some of them are excellent and palatable, others are very inferior. Among those of superior quality are the *Cyprinus carpio*, var. *nudus* and var. *rex-cyprinorum*, the spiegel-carp. The first variety is destitute of scales, having a velvety skin that enhances the table-qualities of the fish. The latter has a row of scales near the dorsal line, and another near the ventral margin. The former is found chiefly in the Lower Danube, and is spoken of as a species very superior in flavor. Among the more inferior ones are *Cyprinus carassius*, the crucian carp, and the hybrids with this and other species.

It is claimed by Francis Francis, editor of The Field, London, England, land, that the carp attains much better qualties in flavor, as a game fish, in large rivers than it does in ponds.*

* Fish-Culture a practical guide to the modern system of rearing and breeding fish By Francis Francis; Pisc. Div. Accl. Soc. of Great Britain. London, 1865.

They are especially valuable because of their adaptation to ponds and even stagnant waters attaining a high degree of heat. In addition to their value as food for man, they will be of great utility in affording a supply of food for those piscivorous fishes it is desirable to propagate; being, it is said, in a considerable degree herbivorous, they can exist in large numbers in the ponds with black bass, glass-eyed pike, or the muskellunge, without reducing the original food of these fishesin the waters, and, of course, increasing it in a considerable degree in the presence of their own young.

The procuring of cheap food for the fishes in the troughs, in the nurseries and the ponds, has been obtained, to a considerable extent, in this way in Germany and Russia, and, it may be, would be found to answer for our brook-trout.

Another fish, the introduction of which is desirable but whose propagation may be left entirely to nature, like that of the black bass, is the gourami, (*Osphromenus olfax*,) a species that is prolific, attains considerable size, of most excellent flavor, and is especially advantageous from the the fact that it is adapted to the warm water-ponds of the warmest temperate and subtropical regions. It can be readily introduced in the southern portions of the United States from China or from Algiers; in both countries it has been introduced, originating in the Malaccan Islands. (See Department of Agriculture Report, 1866, p. 417.)

Although the loss of eggs before hatching has been reduced to an inconsiderable minimum by means of improved methods of impregnation and care during hatching, still there are many things to be accomplished before any high degree of perfection in the culture of fishes will be attained. One of the most important desiderata is the prevention or cure of the omni-present confervaceous growth, (*Achlya prolifera.*) Numerous experiments have been tried by men skilled asfish-culturists and chemists without accomplishing anything that receives general application and approval. The application of salt-brine has been advocated.* Experiments have also been made with solutions of acids and alkalies.

The apparatus for packing eggs in boxes covered with ice and moss, so that the low temperature may retard the growth of the confervæ, has been described on page 547.

At Mr. N. W. Clark's hatching-house the eggs of the white-fish during the past winter have been daily rinsed free from adhering sediment and the developing parasites by agitating the trays containing the eggs in a shallow pan of water. This, though it may appear a rather violent treatment of the eggs, has been kept up throughout the winter without apparent injury, and a large percentage of young fishes has resulted from the eggs thus treated.

A uniform system in the estimation of the numbers of eggs, and consequently a more reliable estimate of the percentages hatched, has been

* On page 174 will be found an account of the method employed to clean the eggs of the *Salmo quinnat* from this foul growth by means of sand and water.

referred to on page 442, under the head of "The artificial culture of the shad."

In order to make the progress definite and rapid, a continued series of systematic observations of the work in the hatching-house is essential. And these should not be confined merely to what many would consider the more practical points in the different processes, but should embrace, in addition many of the minor conditions and phenomena. For instance, in the rather full memoranda of each day's work in shad-hatching in the New York State reports, we have the date, number of shad taken, the number of ripe females, the number of eggs, and the temperature of the water in the morning and at night. From a long series of these observations carefully carried on through a number of years, we might anticipate the working-out of many of the relations between temperature of the rivers and the ascent of the shad; possibly, too, the relation of the ripening of the spawn in the ovaries of the fish to the temperature, in which it is quite probable some very interesting facts may be developed. For example, nearly all shad-fishermen have observed the fact that female shad with full roes are taken to the very end of the fishing-season, and we do not absolutely know that all the mature female shad ripen the ova and spawn before returning to the sea. The addition to the memoranda of the number of ripe male fish obtained would have been of value, as there is evidence indicating that a considerable number of the males are ripe and begin losing the milt before many females are ready to spawn; and toward the close of the season it is often difficult to obtain a sufficient number of males to impregnate the spawn; the record of the number of ripe males obtained would throw light upon this point. In the Massachusetts reports are given the number of fish taken at each haul, and the time of day when the haul was made. These afford data for a knowledge of the movements of the fish while in the rivers, to what extent they are nocturnal, and the like. Among other things, a record of similar character in a trout-hatching house might result in affording an accurate comparison of the vigor and fertility of eggs from domesticated fishes and from wild ones, together with other changes in the fish, as to time of spawning and the like.

E—ALPHABETICAL LIST OF AMERICAN FISH-CULTURISTS AND OF PERSONS KNOWN AS BEING INTERESTED IN FISH-CULTURE.

1.—*Names of persons who are or have been practically engaged in fish-culture.**

Ainsworth, Stephen H., West Bloomfield, N. Y.

Axtell, F. F., Harvard, McHenry County, Ill.

* Corrections or additions, if sent to the United States Fish Commissioner, Washington, D. C., will be introduced into future lists, which it is hoped will more completely represent the statistics of fish-culturists.

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Bowles, B. F., Springfield, Mass.
Bridgman, J. D., Bellows Falls, Vt.
Burnett, Joseph, Southborough, Mass.
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Campbell, Messrs., Mumford, N. Y.
Chandler, Fred., Alstead, N. H.
Christie, H. P., (?) Clove, Dutchess County, N. Y.
Clark, N. W., Clarkston, Mich.
Clift, W., Mystic Bridge, Conn.
Cole, A. P., Whitesville, Allegany County, N. Y.
Collins, A. S., Mumford, Monroe County, N. Y.
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Green, Seth, Rochester, N. Y.
Gridley, Robert, Saratoga Springs, N. Y.
Hagar, Mr. David, Wallingford, Vt.
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Heyford, George O., Dixfield, Me.
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XXII.—PAPERS RELATING TO PRACTICAL FISH-CULTURE.

A—METHOD OF TREATING ADHESIVE EGGS OF CERTAIN FISHES, ESPECIALLY OF THE CYPRINIDÆ, IN ARTIFICIAL PROPAGATION.

BY RUDOLPH HESSEL.

[Translation.]

OFFENBURG, GERMANY, *May* 3, 1872.

In giving the following instruction for hatching the eggs deposited by certain fish in the summer-time, I thought it best to select the species of *Cyprinidæ*, with adhering eggs, for my communication. Such eggs are of larger size compared with those of the other *Cyprinidæ*, and thus the manipulation of impregnation and the observation of the progressing changes are much facilitated. Besides this, it is a fish of great value for table-use and for feeding other fish, and is, in all probability, (though I do not know with certainty,) already introduced into your country, so that you will have no difficulty in procuring male and female specimens for your hatching experiments.

The carp have adhering eggs, and with reference to this peculiarity, the mode of impregnating and the arrangement of my hatching-apparatus are based.

I presume if you cannot obtain any carp, other *Cyprinidæ* with adhering eggs might be substituted; even the percoid *Perca fluviatilis*, (Linné,) which has adhering eggs, would do, as my apparatus is adapted for any fishes of this habit.

I can highly recommend the *modus operandi*, as it has been fully tested by many experiments, provided that your water has similar constituents, is free from contamination by industrial establishments, is of moderately elevated temperature, and, especially, is not infested with spores of the confervoid, (*Leptomitris clavatus*.) With some care, you will have favorable results, but my directions must be strictly followed. You are fully acquainted with the *Cyprinus carpio* and its habitat, and therefore I need not detail my observations made in different parts of Europe during the last twenty years, beyond remarking that it occurs in many of the larger rivers of Middle Europe—the Rhine, Vistula, Elbe, Danube, &c.—and in many lakes. It is especially adapted for ponds, and most of the German villages and estates have ponds where both carp and pike occur together, their propagation being left to nature. It is remarkable that carp thrive equally well in sea-water even attaining better quality and larger size than in fresh. I have fre

quently known this fish to reach the weight of thirty pounds in German lakes and ponds. In Germany, carp are often confounded with hybrids of *Cyprinus carassius*, (*Cyprinus kollarii*, Heckel,) or of *Cyprinus abramis*. Their quality, however, is much inferior to that of the genuine carp.

In middle Europe, carp deposit their eggs in the first summer-days—from the beginning of May to the end of June. In the south, the fish attains a larger size; that is, it grows faster in the same time, since, in northern countries, it is naturally forced into a longer winter-rest. In spring-water it does not thrive at all, requiring warm water in summer-time, with mud at the bottom, and for nourishment, the lower forms of life, (microscopic animal organisms, worms, snails, remnants of plants, &c.)

The eggs are deposited upon water-plants—not those nearest to the surface and exposed to the direct hot sun, but such stems of these *water-plants as are about one inch below*, to which the eggs, when extruded, adhere. Those falling off either perish in the mud or are destroyed by numerous enemies. This peculiarity of adhesion in the eggs, and the usual position of the stems which serve as their depository, suggested the arrangement of my apparatus. This very simple contrivance consists of a number of light, wooden, rectangular frames, about three feet long and one broad, covered on one side with thin gauze or mosquito-netting, (Pl. XVIII, fig. 3.) Upon these screens the impregnated eggs are spread and immediately adhere. After impregnation, (for which directions are given below,) the frames are placed in a floating box, (Pl. XVIII, fig. 1,) the sides of which are covered with some kind of canvas, but somewhat more open than that of the frames, in order to allow a more rapid change of the water, while preventing the escape of the young fish.

The bottom and cover of this box are made of canvas, each box having room for three frames; each frame having on its two sides 20,000 eggs, so that the whole box contains 60,000 eggs. The stuff for covering the frames, &c., must be soaked for some days in river-water, and the size and coloring-matter carefully removed by washing; no soap, however, should be used.

THE IMPREGNATION.

It is, of course, necessary that the fish selected for impregnation should be in a fit condition; the eggs and milt being neither unripe nor overripe, since overripe eggs do not receive the zoosperms well, and overripe milt proves inactive even upon good eggs, its vitality being nearly lost from partial decomposition. If the eggs and milt are immature, so as to require considerable force to express them, no success can be expected. It is always advisable to keep ripe fishes confined in running water for several days previous to the impregnation of the egg.

For the operation itself two persons are required: one, the operator

proper; the other, an assistant. The first frame, which, like all the others, has to be again well cleaned, is placed in a shallow vessel or dish of tin. (Pl. XVIII, fig. 4.) These vessels are to be made expressly for the purpose; two of them being necessary for the operation. Their size is somewhat larger than that of the frames, to facilitate the manipulation; their height, however, must never exceed two inches. These plates have to be carefully cleaned to remove all fatty matter and oxide of tin. Into one of them the eggs are emptied; in the other the impregnation is performed.

The dish is nearly filled with river-water, like that in which the hatching is to take place, of from 72° to 82° F.; its temperature shall be 18° to 22° R., (72° to 81°.5 F.) Then the frame is placed upon the water, and the eggs slowly dropped upon it. The fish is moved back and forward just above the frame, so as to prevent too much crowding of the eggs. As soon as the eggs adhere, the frame is reversed, and the other side treated in the same way. After ten to twenty seconds, this frame, evenly covered with eggs, is removed to the other dish, containing about one inch of water; the milt is then added, or may have been added while the second side was receiving the eggs. Yet there must not be too long an interval between the operations, since the life of the zoosperms of these *Cyprinidæ* is frequently of very short duration. In carp it is scarcely two minutes. The second frame is treated in the same way, while the assistant carries the first to the hatching-box, which ought to be, if possible, at the very place where it is to remain. A repeated addition of fresh zoosperms to the impregnation-dish is advisable. In the same manner, all three frames, with impregnated eggs on both sides, are placed in the hatching-box. The outer frame of this box must be stout enough to keep the perpendicular frames well in place, so that they can neither warp nor fall down. The box must be set where the stream does not exceed twelve inches in depth, with a scarcely perceptible current. One inch a minute is the greatest allowable velocity, just enough to carry fresh water and air. But the apparatus can also be used in stagnant water. The canvas cover is only laid upon the box when the heat of the sun is most intense—perhaps from noon to 4 p. m.—for too much sun is just as injurious to the development of the eggs as darkness.

Every day the apparatus must be inspected and dead or sterile eggs removed. Pincers of wire, about three inches long, and which may be made by one's self, are convenient for the purpose. After three weeks, the eggs will be hatched, and the young fish may be removed to ponds or lakes, wherever wanted. The hatching, in the same manner, can be done in ponds.

Still another mode of breeding is in use here as well as in North Germany and on the Danube. Employing no frames, it is cheaper, yet less convenient for an observer, as the eggs mostly remain hidden and invisible. It has, however, the advantage of simplicity, and thus may be applied

in remote and solitary localities without carrying along previously-prepared apparatus. Pl. XVIII, fig. 5, is a frame made of saplings one to two inches in diameter, such as can be found anywhere in the woods. The several parts are either tied with willow-twigs or roughly nailed together. This frame is made four to five feet long, three feet wide, and one high. It is densely interwoven with juniper or fir brush, while the upper side is left open, and has the appearance of a box or basket of brush. Common or Virginian juniper is most suitable for the purpose, for the inside must not in any way be trimmed—the rougher the better; even some juniper-branches may be laid inside, their rough prickles, indeed, appearing to promote propagation. I have often observed that fishes in smooth willow-baskets, with leaves in, remain lazy and inactive, while others in prickly juniper-boxes were progressing industriously in their work. This basket (Pl. XVIII, fig. 6) is to be set in a warm and sheltered place with two female and one male fish in it. A piece of netting is tied over the top to prevent their escape. The process of breeding is left entirely to nature. In these plaited boxes, *Cyprinidæ* without adhering eggs may also be hatched, when the bottom is dense enough to prevent the eggs from falling through. (To the hatching of *Cyprinidæ* with non adherent eggs, I have referred in a former letter.)

I have thus explained two methods, in accordance with your wish. You will do well to practice both. Mine I have frequently tried and never found wanting. You must, however, not get discouraged in case of failure. Some little mistake or oversight may mar the success. I may as well tell you that at first I failed five or six times, and now my results are always favorable.

The hatching-box must be placed in the water so that the top projects about one-fourth inch above it. Dead eggs have to be removed promptly. After the young fish have absorbed the yolk-bag, they may be left for some days in the hatching-box; but afterward must be fed with mashed brains of cattle, &c., and removed to ponds, &c.

The hatching-apparatus, when in the water, must not touch the bottom, but ought to remain several inches from it. The cover ought always to be one-fourth to one inch above the water. In shallow water, hatching-boxes and frames have to be reduced in height to correspond with the depth.

For operations on a smaller scale, boxes twenty to twenty-five inches long and four inches high are well adapted for hatching *Cyprinidæ* with non-adhering eggs. These should have a solid bottom board, covered with fine, washed sand, and supported by strong floats. They, of course, need no perpendicular frames, as the eggs are deposited upon the sand, neither is any shading required, however burning the sun may be.

B—ON THE SO-CALLED "DRY" METHOD OF IMPREGNATING SPAWN.

From Circular No. 3, 1874, published by the German Deutsche Fischerei-Verein, Berlin, June 22, 1874.

[Translation.]

Following a suggestion made in Circular No. 1, 1874, I have the honor to lay before the public the results of a method of dry impregnation practiced by me since 1857, which, if properly carried out, is sure to be successful.

As I have not read the articles on the subject contained in Circular No. 4, 1871, and in Circular No. 6, 1873, I am not able to say whether the "Russian dry method" recommended by Livingston Stone is similar to mine; the term "dry method," however, makes a similarity of both methods very probable.

In the autumn of 1854, I established at Wernersdorf, district of Balkenhayn, province of Silesia, some trout-ponds, and it was my first care to provide some cheap living food for the young trout placed in these ponds in the spring of 1855 and 1856. For this purpose, I had made, close to one of the ponds, a spawning-basin with flat shores and separated from the pond by a railing. In this basin, I placed some carp, the young of which could through the railing escape into the pond.

As there were older trout in the other ponds, I likewise endeavored to raise young fish for these, and selected the "nase," which spawns in large numbers in the river Bober in April, and is in those parts commonly called "zupe," (*Chondrostona nasus*, Sieb., *Cyprinus nasus*, Lin. and Bloch.) These fish spawn in large numbers in the shallow stony places in the middle of the bed of the river Bober, places over which the water flowed rapidly and producing considerable waves.

In April, 1856, I placed a large quantity of the roe of this fish—which is easily extracted—in flat vessels filled with Bober water, and after a brief interval I poured in the ripe milt, stirring it with a quill-pen. This method of impregnation differed in no respect from the one I had always successfully employed with trout-spawn. The result of this artificial impregnation, however, was an entire failure.

The eggs, after having been placed in the water, swelled very rapidly on account of the sticky layer surrounding them, so that no impregnation could take place.

Although I noticed this rapid swelling of the eggs, and their considerable stickiness, as after a short while they stuck so firmly to the bottom of the vessel that it could be placed upside down without their falling out, I did not find out the cause of this failure till I saw that there was no normal development of the impregnated eggs, but that they were entirely spoiled.

I determined at my next attempt to pour the milt in immediately, and

thought that by doing this very rapidly I might insure success. The spawning-season of the "nase" for 1856, however, was over, and I had to defer my experiments till April, 1857. In that month the "nase" spawned in exceptionably large numbers and several times; I consequently had an opportunity of watching them closely during the spawning-process, and the observations I then made led me into the right path.

Very frequently two fish would leap close together from the water, which led me to suppose that during this violent motion the spawn which sits very loosely in the body of the fish, and the milt which flows off very easily, might be dropped in the air, and that the eggs might possibly be impregnated by the milt before they touched the water.

Although I, of course, could not observe the very act of impregnation—which, as I supposed, took place—during the very short time occupied by the leap of the fish, it became almost a certainty to my mind when I took into consideration the exceedingly violent motion of the fish and the extreme ease with which both the milt and the roe are emitted.

I was led to make further observations, proving the fact that fresh spawn when brought into contact with water swells very rapidly and sticks to any objects that present themselves, by seeing several tame ducks devour very eagerly the spawn found on the stony bottom. When taking up some of the stones, I chiefly found their lower surface thickly covered with spawn.

I must here remark that the strong current in these spawning-places indirectly contributes to the better protection of the spawn by driving it below the stones. If the spawning took place in gently-flowing water, the eggs would stick to the upper surface of the stones, and be exposed to many enemies.

I now made experiments with four different methods of impregnation, using only entirely healthy and mature fish, of which I could easily procure a large number. These fish were caught while spawning, and on the spot experimented upon.

1. I again used the "wet" method of last year, with this difference, however, that *immediately* after having squeezed the roe out of the fish, the milt was stirred in. This was done as rapidly as possible; at any rate, much quicker than the year before.

2. Assisted by a man, I poured into a flat vessel, filled with Bober water, milt and roe *at the same time*, stirring the water immediately.

3. Into a flat vessel containing but little water, I poured *first the milt*, so that after stirring the water immediately, it had a whitish color; then without delay I poured the roe into this mixture.

4. A fish containing roe was dried carefully and rapidly with a cloth, (occasionally, also, with the hands,) and the "*dry*" roe placed in a flat vessel containing no water. Over this was placed the milt of a fish, (that had likewise been dried beforehand with a cloth,) so as to cover the largest possible number of eggs. As soon as this was done, water was

poured over the whole mixture, and the whole was stirred immediately. The pouring-over of the water and the stirring was, if possible, done simultaneously, almost suddenly.*

The result of experiment No. 1 was a failure.

Of Nos. 2 and 3, only a few eggs out of several thousands developed, so that these two methods must likewise be considered failures.

In No 4, all the eggs were regularly developed with but very few exceptions. This method must therefore in every way be considered a success. It was proved conclusively that ripe eggs fresh from the fish when brought into contact with water immediately swell to such a degree that the sticky layer surrounding the eggs prevents the spermatozoa from entering the interior of the egg, impregnation thus becoming impossible. It is likewise proved almost to a certainty that during the natural spawning-process of the "nase," the milt touches the roe outside of the water, and that the water completes the begun process of impregnation.

This may therefore well be called *nature's own method of dry impregnation.*

I have at the same time, with many other comparative experiments, very frequently employed this "dry" method, especially with salmon-trout, and have in all cases been successful.

To insure complete success, the following rules and precautions must be observed:

1. The vessel used should be as flat as possible, and should, by rubbing it with a cloth, be completely freed from any dripping water; the inside of the vessel may remain a little damp.

2. As the temperature of the air but rarely corresponds with the temperature of the water, the vessel should externally, for some time, be brought into contact with the water to be used for spawning. This should be done so long before pouring in the roe as the length of time required for equalizing the temperature throughout the whole body of the vessel. If the difference between the temperature of the air and the water is not very great, neglecting this precaution will not prove injurious. It should, however, never be neglected when these temperatures differ greatly, or when the temperature of the air is below 0°, (Réaumur.) The vessels should not be taken out of the water before the end of the above-mentioned period.

3. Place in readiness both the fish, the one containing the roe and the one containing the milt.

4. First carefully dry with a cloth the fish containing the roe, avoiding the slightest pressure, so as to prevent the premature emission of the loose spawn; hold the fish in a horizontal position, and dry your

* The claim made on pages 541–543, for the discovery of a literally dry method of impregnation by American fish culturists, will have to be abandoned in favor of European specialists. It will be seen by reference to pp. 515 and 577 that Dr. Vouga, of Switzerland, and Professor Rasch, of Norway, have adopted similar methods.

hands carefully so that water could nowhere gather. Then pour the roe in a "dry" state on the bottom of the vessel.

5. If the drying-process has been well done, so that no swelling of the eggs can take place, take up without any too great hurry the fish containing the milt, dry it like the other one, and pour the milt over the eggs so as to cover the largest possible number. A quantity of milt which only gives the water—to be poured in afterward—a slightly whitish color is sufficient. The pouring over of the milt should be done quickly. With fish of the species of *Salmo* and *Trutta* a quarter of an hour may intervene between putting the roe in the vessel and pouring in the milt, provided all the other conditions are favorable.

6. As soon as the milt has been poured in, pour over the water as quickly and as suddenly as possible, so as just to cover the eggs with water, and stir the mixture with the hand, letting it rapidly describe a circular motion on the bottom of the vessel.

7. Let the whole stand for a while, this period of standing to be regulated by the degree of stickiness of the roe and its power of swelling; sometimes amounting to less than a minute, sometimes to more than an hour. The impregnation commences in a short time, and it is therefore advisable to clear the milky water after a few minutes by pouring in clear water. The object of this period of standing is to diminish the sticking capacity of the eggs, which is strongest in the beginning, but which constantly decreases; also to insure in some species of eggs their complete development to the quickly-increasing spherical form, to make them gradually grow harder before placing them in the transporting-vessels, and thus to prevent their pressing each other too much.

8. Before placing the impregnated roe in the transporting-vessels, loosen it carefully with a quill-pen from the watery bottom of the first vessel.

9. Never fail to select vessels of considerable size for such species of roe as swell rapidly, so that the eggs can lie loosely without pressing on each other. All vessels used for this purpose should therefore have a flat bottom.

Whenever the milt is scarce, it may be recommended to use smaller vessels, so as to concentrate it as much as possible. Whenever this is done, it will be well, after having stirred the roe and milt with water, to pour it into a larger vessel with some water, and let it stand in this.

If this is neglected, the eggs will frequently be exposed to too great a pressure. Such eggs as do not contain the necessary space for developing the young fish will produce weak or deformed fish. With roe of the species of *Salmo* and *Trutta* this precaution is unnecessary, as well as with all those species of eggs which do not change their shape when exposed to pressure.

To employ the "dry method of impregnation" in *all cases* is not advisable, as the "moist" method is simpler, and in most cases proves successful. The "dry" method, however, must *absolutely* be employed with all those

species of roe which swell *immediately* when brought into contact with water, thus preventing the entering of the spermatozaa, and under all circumstances it is a method which can be highly recommended:

1. When operating on species of roe which does not swell rapidly, and when loss of time between pouring in the milt and the roe, endangers success. With the roe of the *Coregonus* this loss of time is but very brief; with that of the species of *Salmo* and *Trutta*, in employing the "moist" method, about five minutes.

2. When you have only one fish containing milt for several containing roe, or whenever the quantity of milt is small.

3. Whenever roe is to be impregnated whose nature, when brought into contact with water, is not well known.

Every pisciculturist has, no doubt, often made the experiences mentioned under Nos. 1 and 2. The case mentioned under No. 3 came under my personal notice on the 25th of November, 1869, while artificially impregnating the roe of the *Coregonus marœna.* The nature of this roe was, at the time, new to me. As a precaution, I employed the "*dry*" *method*, which under *all circumstances is more certain of success*, in the presence of the royal superintendent of fisheries, Mr. Jeserich, and other gentlemen. *Every one of the eggs* operated upon was developed successfully.* In the year 1872, during the month of November, I repeatedly succeeded, by the "dry" method, in impregnating the roe of *Coregonus Wartmannii* in Lake Puls, in the district of Soldin, province of Brandenburg, because of the circumstances mentioned under Nos. 1 and 2. The eggs impregnated in this manner developed regularly and very successfully.

After all my experiences in employing the "dry" method, I can vouch for its successful results, provided the above-mentioned precautions are taken.

If this method is not successful, the failure must be ascribed, not to the method itself, but to other circumstances.

TANKOW, *April* 6, 1874.

ALEXANDER STENZEL,
Inspector of Fisheries.

C—FISH-CULTURE IN SALT OR BRACKISH WATER.

BY THEODORE LYMAN, *Fish-Commissioner of Massachusetts.*

When shores are not bold, and have extensive shallows, there is often a considerable zone of sea which produces few valuable fishes, although swarming with fry and with small crustacea and mollusca. In Norway

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* As the piscicultural establishment at Tankow was not commenced till the middle of November, 1869, there was a lack of suitable water for receiving the roe of *Coregonus marœna.* In the beginning, it developed regularly, but was soon spoiled by the impurities of the water and its low temperature. Some eggs placed in purer water, with a higher temperature, developed fish which reached the age of three weeks. During this spring, (1874,) the *Coregonus marœna* has been raised successfully.

attempts have been made to use portions of such shallows for the raising of marketable species.

It is well known that the growth of the trout, as a genus, is peculiarly affected by large supplies of food in salt-water. Thus, the salmon-smolt, which goes to the sea weighing a few ounces, returns as a grilse of three or four pounds. Our brook-trout, so long as it is confined to the meager insect diet of a shallow mountain-rill, scarcely grows beyond the size of one's finger; but, with access to salt-water in late winter and in spring, it takes on a silver coat, and with surprising rapidity attains a weight of one or two pounds.

The experiments of Professor Rasch have shown that these desirable results may be attained without allowing the fish to wander in the open sea. It suffices to inclose a space of brackish or salt water, and to keep the trout within those limits. There are two essentials: (1.) A brook emptying into salt-water. (2.) A narrow cove, inlet, or fiord making the continuation or mouth of such brook. If this inlet has a pinched place in it, so much the better, because there will be the economical spot to throw across a dam, or a grating, to bar the passage to the open sea. Usually some form of dam is desirable, so that when the tide ebbs, a certain depth of water shall be held back in the salt-pond thus formed. The barrier should not be of uniform height, because then the pond, becoming quite stagnant on the bottom, would gradually fill with mud brought down by the brook. To obviate this, a vertical cut should be left open to keep up the bottom current, (Plate XIX, Fig. 1 *a*.) The width of this cut must be such as to discharge the flow of the brook; otherwise it would rise and pour over the whole of the dam-crest, and the fish would pass over also. Further, to provide against such an accident and to give free passage to the flowing and ebbing tide, an ample waste-way, lower, of course, than the dam-crest, must be built next to, and continuous with, the cut, (*b*.) As to the crest of the dam, it must be raised higher than the level of the highest tides. It must be built, of course, solid, and of such material and with such foundations as its situation demands. If, as often occurs, there is a stratum of salt-mud, the foundations must be built quite close, to prevent musk-rats from working through; for one hole is enough to let out the greater part of the fish. The waste-way should be of ample width not only to let out the water of the brook in case of a flood, but to freely admit the tide, which brings in food. It must be carefully grated, together with the cut, which is sunk lower. It requires some calculation so to arrange gratings that they will not get clogged with drift material. They must be arranged on the principle of coarser and finer sieves. On the pond side, and well out from the waste-way, the first grating may be put, with stout bars, five inches apart, (Figs. 2, 3, *c c*;) within this a second, with bars two inches apart, (Figs. 2, 3, *d d*;) after this, a central grating, which is the important one, intended to stop the fish, (Figs. 2, 3, *e e*.) It should be carefully made of one-quar-

ter-inch vertical rods placed, with one-half-inch gaps, in a hard-pine frame, and braced with horizontal wires, (Fig. 4, full size.) On the seaward side one screen, (Figs. 2, 3, *f*,) made like *d*, will be sufficient; and the stout screen *c* may be omitted where there is no fear of floating logs or branches. As the crest of the dam must be *higher* than the highest tide, so also the bottom of the waste-way must be *lower* than the lowest flood-tide, in order to insure the entrance of the sea-water at every flow. The changes of level produced by this dam will be understood through Fig. 5. The dark portion is a section of the old bottom, the marsh in the center and the upland rising on each side; the deep depression in the middle is the old bed of the brook. In its natural state, the brook, at low tide, would only fill its banks to the line A B; at high tide, the water would be backed up to the line E F. When the dam is built, the water, at low tide, would be as high as the line C D, because the deep cut *a* is narrower than the natural bed of the brook; at high tide the level would be the same as without a dam, namely, E F. The advantages gained are: first, that while a flow of water is still kept up, the depth and surface are much increased by raising the level; and, secondly, the fish, by means of the grated cut and waste-way, are prevented from wandering. A brackish pond thus made would have a brook (Fig. 6, G) running in at its upper end, where the water would be shallow and fresh, E; while at the lower end it would be deep and more or less salt, F; and the deeper the better, for this breeds big fish. The *Salmo lacustris* of Western Europe, and the great thirty-pound trout inhabiting the Norwegian lakes, some of which are three hundred fathoms deep, are considered by Professor Rasch as only overgrown individuals of the common European brook-trout, *Salmo fario*. Our own brook-trout, *Salmo fontinalis*, is known to attain to twelve pounds in our Maine lakes, where the water is deep and food plenty. In water brackish, or nearly salt, and crowded with crustacea and small-fry, the depth does not count for so much; and a trout will pass from one to two and from two to three pounds rapidly, although he may nowhere find holes more than five feet deep.

Two such ponds as have just been described were laid out by Professor Rasch in 1869; the one covering some seventy-five acres, at Sandvigen, near Christiania; the other of two hundred and seventy acres, and with a maximum depth of thirty-eight feet, not far from Frederickstad. The tide in the last ramifications of these Norwegian fiords is very slight, not exceeding one foot; so that a low and cheap dam is sufficient. In a rough slab shanty, twelve feet square, he hatched 80,000 salmon-eggs in one season. The apparatus inside was equally primitive; only a set of narrow board troughs, arranged step-fashion, and emptying into each other by notches cut in alternate ends. Some gravel was placed in the bottom of these troughs. A wooden pipe brought in the water from a neighboring spring. There were no filters, stop-cocks, or tanks.

Professor Rasch collects the eggs, *dry*, in a basin, which has simply

been sponged with water; then the milt is squeezed over them, and, finally, a small quantity of water is added, while the basin is tilted to and fro. If the egg be kept thus dry, the micropyle will remain open for several hours; but in water, the egg immediately begins to swell and the micropyle closes, shutting out the spermatozoa.*

As soon as the hatched fry had absorbed their yolk-sacs, they were turned loose in the brook, where they grew during the parr stage, feeding in the brook itself, or in the shallows of the upper pond. Taking on the smolt coat, they descended toward the lower end, seeking the salt-water, when, as ill luck would have it, they found a small hole, and the greater part escaped, some of them returning next spring to the foot of the dam. Enough, however, remained to show that the smolt will continue his growth when confined in a salt-water pond. Trout, which were raised beside the salmon, were more quiet and did not escape. They throve amazingly and grew to a great size.

The owner of an artificial brackish pond may either depend on the natural increase of the fish that were before in the brook, or he may add fresh material. If he depends on natural breeding, he will place adult fish in the brook where they will breed. Or he may have a hatching-house, which could be placed near the brook, and in which young fry could be raised to be set free in the shallowest portions of the water.

In a pond and brook of good extent, several species would doubtless do well, living side by side. Such species and varieties as the true salmon, the land-locked salmon, sea variety of the brook-trout, the Sebago salmon, and the forkep-tailed salmon-trout of the great lakes might profitably be cultivated. In addition to these, Professor Rasch recommends hybrids, which are never fertile, and which are therefore fat and in good condition during the breeding-season. Mr. Hanson, of Stavanger, on the west coast of Norway, has observed that a hybrid from the brook-trout (*Salmo fario*) and the charr (*S. umbla*) grows much faster than either of these species, because none of the flesh and fat producing materials are expended in developing the large organs of reproduction. Taking our brook-trout as one, the breeder might select the other fish from such as were at his command. Doubtless some near species, such as the togue of the Maine lakes, or the forked-tailed salmon-trout of the great lakes, would yield the surest impregnation.

D—DESCRIPTIONS OF IMPROVED APPARATUS IN FISH-HATCHING.

1.—SHAD-HATCHING OR FLOATING BOXES.

Seth Green's box.—The devices used in shad-hatching are, first and

* The dry method of impregnation has since been successfully tried by Mr. Atkins in breeding salmon.

most important, Seth Green's box,* (Pl. XVII, Figs. 1 & 2,) patented, which has been longer and much more extensively used than any other. It is an ordinary box, made of inch-boards, and covered on the bottom with wire-cloth painted with coal-tar or naphtha varnish, and with two cleats made of scantling nailed obliquely to the sides of the box, which act as floats; these incline the box so that it stands with the bottom presented toward the current at an angle of about 60° in an ordinary tide-current, creating a slight but sufficient circulation of the water in the box to keep the eggs from lying entirely inert at the bottom. Six or more boxes are tied together in a string or gang, and anchored a short distance from the shore.

Brackett's box.—Another box patented, used by Mr. Brackett for the first time in 1873, is arranged to float horizontally in the water; the end presented to the current sloping inward and backward, so that the bottom of the box is of less length than the top. A circulation is produced by the downward deflection of the current, which creates an eddy directly beneath the wire-cloth bottom of sufficient strength to agitate the water and the eggs within the box.

Stilwell and Atkins's box.—Another plan has been suggested by Mr. E. M. Stilwell, fish-commissioner of Maine, and Mr. Charles G. Atkins, of

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* *Device for hatching the spawn of fishes.*—United States Patent-Office.—Seth Green, of Rochester, New York.—Letters-patent No. 68871, dated September 17, 1867.

(The schedule referred to in these letters-patent and making part of the same.)

To all whom it may concern:

Be it known that I, Seth Green, of Rochester, in the county of Monroe, and State of New York, have invented a new and useful "method of hatching fish-spawn;" and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawing, making part of this specification in which the figure is a vertical central section of my invention, represented as applied in the water.

This invention relates more especially to the propagation of shad, and its nature consists in the peculiar construction and arrangement of a propagating or fish or frog-spawn hatching-chamber in such a manner as to effect a perfect and uniform circulation throughout the entire chamber, and at the same time prevent the escape of the spawn, and also of the young fish, until the attendant thinks proper.

To enable others to make and use my invention, I will describe its construction and operation.

I provide a rectangular box, A, of any desired size or proportion. I prefer them, however, about two feet long by eighteen inches wide and ten or twelve inches deep. I provide a suitable square opening in one end, as shown at B. This opening is covered upon the inside of the chamber with a fine wire screen, about No. 12, and upon the outside is hung a cap, C, which may be pivoted above, as shown, and made to swing down over the opening, or it may be made to slide over it horizontally. I also provide the open bottom with a similar wire screen, D, but of finer mesh. I attach a shallow frame, F, to the lower edge of the chamber or case A, outside of the screen. There may be one or more cross-bars, E, but they should be made thin on the upper side as shown, to prevent the lodgment of any of the spawn upon them, as the spawn will only hatch well when buoyed up in the water by a perfect circulation. I attach a float-bar, G, obliquely across each side of the case or chamber A, and to one end of these I attach a

the salmon-breeding establishment at Bucksport, as illustrated in the accompanying diagram and its explanation. (Plate XVII, Figs. 4 & 5.)

The drawing represents the box in the position it assumes floating in the stream; a portion of the nearest end removed to show the bottom. The left face is presented to the current, and the water enters in the direction represented by the arrow. Circulation is produced by the movement of the current up the inclined bottom, which carries the eggs with it, to fall back again in the recoil from the back of the box. When left entirely to itself, it floats in such a position that the bottom is at an angle with the surface of the stream, and this angle is to be in an opposite direction to the current from that of Seth Green's box, and can be increased to whatever extent desired by weighting the front of the box.

2.—TRAY-APPARATUS FOR HATCHING.

Holton's tray-hatching apparatus.—United States Patent-Office.—Marcellus G. Holton, of Rochester, N. Y., assignor of one-half his right to Seth Green, of same place.—Improvement in fish-spawn hatchers.—(Specification forming part of letters-patent No. 136834, dated March 18, 1873.)

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suitable anchoring-cord, *c*. They are connected together a few feet from the bars, and continued in one cord to the anchor *k*. The chambers may be cut down, as shown, or they may be left full, as indicated by the dotted lines *d*. The floats F may be very much lengthened, if desired, and a series of cases attached to them, or there may be a long case made and provided with suitable divisions and anchored across the stream, from each end, but I prefer to have the cases made separate, and in size and proportion about as first described. They should be arranged more or less obliquely upon the floats F, according to the rapidity with which the current runs in which they are to be anchored. The obliquity shown in the drawing I find well adapted to a current running about two miles per hour, for shad, which affords a perfect circulation, just sufficient to keep the shad-spawn perfectly buoyed in the water, and all exposed to a gentle agitation. In a faster stream or current, the case should be arranged flatter upon the floats, and *vice versa*.

The spawn to be hatched in this apparatus is prepared in the usual manner for artificial hatching. The cases should be carefully watched. They should be anchored in a current for shad, but may be anchored in still water for certain other varieties of fish, and for frogs. As soon as the spawn is hatched, the plate C is raised and the young shad pass out through the screen N. The case must only be opened after dark, for shad, as the smaller fish which would take the young shad only feed during the day. This gives the young shad an opportunity to take care of themselves as nature dictates.

The ends or sides, either or both, may be made of wire or cloth screens, with a bottom of the same, or it may be made close, but I prefer the construction principally shown and described. It will be seen that by this plan the spawn is all exposed to the circulation necessary, and is entirely relieved from all sediment or other obstructions or tendencies to prevent a perfect hatching.

What I claim as my invention, and desire to secure by letters-patent, is—

The employment or use of the fish-propagator or spawn-hatcher, constructed and arranged substantially in the manner and for the purposes herein shown and described.

SETH GREEN.

Witnesses:

WM. S. LOUGHBOROUGH.

FRED. A. HATCH.

To all whom it may concern:

Be it known that I, Marcellus G. Holton, of Rochester, in the county of Monroe, and State of New York, have invented certain improvements in pisciculture or fish-spawn hatching, of which the following is a specification:

The object of my invention is to provide a simple and convenient method of fish-spawn hatching, which may be practically carried on during the winter-season. Its nature consists, mainly, in the employment, in connection with the spawn-trays, of an upward current or flow of water through the layers of spawn, affording a thorough and constant circulation of fresh water through the same.

In the drawing, (Plate XIV, Figs. 1, 2, and 3,) Fig. 1 is a vertical central section of one case of trays; Fig. 2 is a top or plan view of the same; Fig. 3 is a transverse sectional view of the cylindrical bottom B.

A represents a square box or case, made water-tight, preferably of wood, and provided with a concave bottom, shown at B, or a hopper-bottom might do as well, the object being to cause any sediment, &c., to be easily removed through the discharge-pipe *p*. There is a channel, C, formed entirely around the case near the top. The outer walls of such channel are somewhat elevated above the upper edge of the case proper. This permits a gentle overflow from all sides of the tray-chamber, near the bottom of which is fixed a ledge, *i*, Fig. 1, upon which the trays *c* may rest. These latter consist of shallow rectangular frames, each provided with a fine wire-gauze bottom, upon which the spawn is deposited and held during the time of hatching. There is a suitable metallic or other strap, *s*, attached to two opposite sides of the bottom tray in each case of trays, whereby the whole set may be raised or lowered as may be necessary in removing or replacing them, as hereafter more fully described. There is a vertical recess cut in the sides of the case to receive the straps. The latter are perforated at distances corresponding to the vertical depth of each tray; and the straps, if made of metal, may be provided with a suitable pin, *a*; but if leather is used, they may be hooked upon a fixed pin in the upper edge of the case. A pipe, P, may be used to conduct the water from the spring or fountain into the bottom of the case; or a water-chamber may be formed entirely across that side of the case and also across the bottom. This latter construction is rather preferable for all except the first case in each tier, and, in fact, would not be objectionable for that. To insure a thorough distribution and circulation of the upward-flowing current of water through all parts of the trays, I provide the deflector *h*, which may be spherical, as shown, flat, or any other suitable shape. It is supported directly over the inlet-opening *d* upon suitable standards *n*. The discharge spout or trough *f* conveys the overflowing water to the descending water channel or chamber of the next succeeding case.

The case may be made of any desired size; but I prefer them about eighteen inches to two feet square, and from two to four feet or more in height, according to the amount of fall afforded to the water from the spring or fountain.

The cases may be arranged in tiers the whole length of the floor of the hatching-house, and the water overflowing from one made to pass into and through the next succeeding one to any desired extent as to numbers.

The lower tray is suspended, when it is to be filled, in the position occupied by the upper tray *c'*. The spawn is deposited evenly over the surface of the wire-gauze, and in a suitable quantity. The tray is then lowered by the straps *s* sufficiently to permit the insertion of another tray, which is treated in a like manner, and so on until the case is filled. The trays and young fish may then be removed in a similar manner—that is, one tray at a time—and the water allowed to flow through during either process.

It will be seen that the spawn will remain evenly distributed on account of the longitudinal position of the trays; and, by means of the buoyant tendency of the upward current, there is no damage or loss of spawn by lack of circulation.

This plan is intended more especially for winter-hatching, or for the spawn of white-fish; but it may also be used for almost any other kind.

What I claim as my invention is—

1. The spawn-hatching apparatus A, constructed as described, to produce an equally-distributed upward flow or circulation of the water, for the purposes set forth.

2. In combination with the spawn-hatching apparatus A, the overflow-channels C, arranged to equalize the overflow on all sides, substantially as and for the purposes set forth.

3. In a spawn-hatching device, the trays *c* and water-inlet opening *d*, in combination with the deflector *h*, arranged to operate substantially as and for the purposes shown and described.

4. In combination with the spawn-trays *c*, the concave or hopper-shaped bottom B, substantially as described, and for the purposes set forth.

M. G. HOLTON.

Witnesses:

WM. S. LOUGHBOROUGH.
PATRICK MCINTYRE.

Clark's tray-hatching apparatus.—Nelson W. Clark, of Clarkston, Michigan.—Improvement in fish-hatching apparatus.—(Specification forming part of letters-patent No. 148035, dated March 3, 1874; application filed January 7, 1874.)

To all whom it may concern:

Be it known that I, Nelson W. Clark, of Clarkston, in the county of Oakland, and State of Michigan, have invented an improvement in fish-hatching houses and boxes, of which the following is a specification:

The nature of this invention relates to new and useful improvements in the construction of hatching-boxes, and their arrangement in a hatching-house, and the arrangement of the other necessary parts to secure economy and safety in the manipulation of the eggs, and to preserve the fish after being hatched. The object of the invention is, first, to avoid the use of gravel as a hatching-bed, so that all danger of disturbing the eggs may be avoided, and which attends cleaning them from the deposit of silt or earthy matter, which, more or less, obtains when the gravel-beds are employed; second, to enable the manipulators to easily remove the dead eggs while immersed in water of the same temperature as is used in the hatching-troughs; third, to preserve the fish, when hatched, within the boxes wherein they were hatched, and whence they may be easily and safely removed, when desired; and, fourth, to not only save labor, but to insure the hatching of more eggs than in the hatching-troughs usually employed.

Fig. 1 is a plan view of a section of a hatching-house built upon my improved plan. Fig. 2 is a vertical section on the line *x x* in Fig. 1. Fig. 3 is a plan view of the cross-bar which retains the hatching-box in place in the troughs, and at the same time confines the perforated top of the hatching-boxes. Fig. 4 is a sectional perspective of one of the hatching-boxes with the perforated top or cover in place. Fig. 5 is a perspective of one of the water-ways or channels which leads from one compartment of the troughs to another. Fig. 6 is a perspective of an inverted hatching-box.

Like letters refer to like parts in each figure.

In the accompanying drawings, A represents the walls of a hatching-house, provided at one end with an elevated water-tank, B, from which the water flows through pipes or faucets *a a'*, as desired. C are the various compartments of the hatching-troughs, made water-tight, and the walls and divisions somewhat higher than the hatching-boxes D, and so provided with waste-water ways or channels *b* that the water in the troughs shall never flow over the tops of the boxes. These latter are constructed somewhat smaller than the compartments in the troughs wherein they are placed, and they are provided with feet *c* to raise them sufficiently from the floor of the troughs to allow a free passage of water under them, and to raise them above any sediment that may be deposited on said floor. The bottoms of these boxes are covered with a fine wire-gauze, sufficiently fine that the fish, when hatched, cannot pass through the meshes. Small risers *d* are secured to the ends of the boxes just above the bottom, and upon these bottoms are placed a portion of the eggs to be hatched. A series of sieves, E, the meshes of which are fine enough to retain the eggs placed therein, and large enough to per-

mit a free passage of the young fish, are successively placed, one above the other, in the boxes, until the same are nearly filled—each one of these sieves having its proportion of eggs deposited thereon. A pan, F, made of perforated sheet-metal, is then placed as a cover to prevent the eggs from floating. The hatching-boxes, being thus prepared, are placed one in each compartment of troughs C, and with one end resting against that side of the compartment whence the water is received. A cross-bar, G, is then inserted into small slots *e* in the sides of the troughs, and resting upon the tops of the boxes prevents them from floating when the troughs are partially filled with water. These cross-bars are provided with feet *f*, so adjusted that, when the bar is in place, the feet will rest against the perforated cover and prevent it from floating. When all the boxes have been thus placed and secured in the various successive compartments of the troughs, the water is let on through the pipes or faucets hereinbefore described as leading from the tank B, and falls on to the perforated covers of the boxes in the first compartments of the trough, and by means of the perforations in the covers is equally distributed over their surfaces, and runs down through the eggs upon the sieves below, supplying them with constantly-changing fresh water, and washing the eggs thoroughly, carrying down any sediment or impurity and depositing it upon the floor of the trough. As the first compartments fill with water, the waste-ways *b* allow it to pass on to and through the boxes in the next compartments of the trough, and so on, successively, until the water is finally discharged out of the hatching-house in any convenient way, and at the end opposite the tank. Great care must be taken to so arrange the waste-ways that the water will be discharged from one compartment into the next succeeding one before it reaches such a depth that it would flood or run over the sides of the hatching-boxes. At its lower end each one of these water-ways is provided with a perforated or wire-gauze screen, *h*, to prevent the possibility of the fish, when hatched, passing from one compartment to another. When the hatching is complete, the cover may be removed from the boxes and the young fish removed at will.

Many eggs, in the process of hatching, die, and it becomes necessary to remove the dead eggs to prevent injury to the others. To accomplish this, near each series of compartments there is placed a shallow trough, H, into which the water is fed from the tank B through the faucet a', as shown. An operator removes one of the sieves from the hatching-boxes and places it in the trough H, through which the water of the same temperature flows from the tank, and of sufficient depth not to float the eggs. The dead eggs are removed in the usual way, and the sieve replaced in the hatching-box. The screen *h* is placed across the discharge-end of the water-ways, and is to prevent the small fish from ascending the current. Ordinarily screens are so placed and the hatching-troughs so arranged that the fish are carried down with the current against the screen, choking the same, and damming the water until it overflows, carrying with it great quantities of fish, which are thus lost.

By my plan of confining the fish, when hatched, to the boxes wherein they are hatched, they can never escape into the troughs, and, consequently, cannot get into the current through the waste-ways and choke the screens. The passage of the water down through the boxes is so broad, being the full size of the interior of the boxes, that the fish are not carried or forced downward, but they rise naturally, and these screens *h* are placed, as described, to prevent the fish from passing up the current.

What I claim as my invention, and desire to secure by letters-patent, is—

1. A fish-hatching house, wherein the water-tank B, hatching-troughs C, hatching-boxes D, cleaning-trough H, and water-ways *b* are constructed and arranged with relation to each other, substantially as and for the purposes herein set forth.

2. In combination with any suitable troughs, C, the hatching-boxes D, provided with feet, *c*, gauze-bottom sieves, E, and a perforated pan-cover, F, arranged to receive the water in the pan on top and discharge it below, substantially as and for the purposes specified.

3. The cross-bar G, constructed as described, in combination with the troughs C and hatching-boxes D, for the purposes set forth.

4. In combination with hatching-boxes, the perforated pan-cover F, as described, and for the purposes set forth.

NELSON W. CLARK.

Witnesses:

C. E. B. HUESTIS.

H. S. SPRAGUE.

Williamson's hatching-box.—[From the California Mining and Scientific Press, February 28, 1874.

To those persons engaged in fish-culture on a large scale, an improvement in hatching-boxes, recently perfected by Mr. John Williamson, secretary of the California Acclimatizing Society, will be of interest. We give an engraving of this box, which possesses some peculiar features. Mr. Williamson calls it the improved double-riffle hatching-box. Its special features can easily be seen by reference to the cuts. The upper figure shows a trough with light hatching-boxes, and the lower figure is a section of the box one-quarter of the full size. The usual way of arranging these hatching-boxes is to place the eggs on the bottom, and allow the water to flow over them. A box, the same size as the one represented, will then hold 20,000 eggs. Mr. Williamson puts in the box five trays 19½ inches long and 18 inches wide, with a frame three-quarters of an inch thick and one inch wide, with a wire bottom having eight squares to the inch. By this means, he has space to hatch 120,000 eggs, where he only had before, in the same box, space to hatch 20,000 eggs. This is of great importance in hatching-houses where room is desirable. The

hatching-box holding the trays is made of $\frac{1}{2}$-inch ends and 1-inch bottom. The ends are 5 inches high. The water is made to flow in under the upper end and out over the lower end, as the arrows indicate. By this means all the eggs are thoroughly covered by constantly-changing water, and less sediment is deposited on the eggs. The end of each box near the head of the trough is made higher than the lower end, to cause the water to flow in the manner indicated. The trough is 16 feet long, 8 inches deep, and 18 inches wide. The longitudinal section is made on a scale of one-half inch to the foot.

Seth Green, the great fish-culturist, used a trough somewhat similar, but he led the water in and out of each box by means of a pipe, which caused a steady flow only near the mouth of the pipe. In Mr. Williamson's box, the flow is equal on all parts, and the eggs have plenty of fresh water. The upward current runs up through all the eggs, and the eggs being on top the sediment does not collect on them. There being so much more surface to place eggs in the same relative space, considerable room is saved in the hatching-house.

The California Acclimatizing Society are beginning to use these boxes at their hatching-house at Point Pedro, in San Mateo County. The device is not patented.

3.—THE BROOK-SHANTY.

An apparatus for fish-hatching, called the Brook-Shanty, was invented and patented by W. H. Furman, of Maspeth, Queens County, New York, in 1868.

This consists of a building, either inclosing a section of a stream with a dam shutting off the water from above, except as it passes through an inlet into the building, or without relation to a brook, admitting water from springs into the building. Within the building, raised above the inlet, a spawning "chamber" containing troughs is arranged. The troughs are covered with gravel to considerable depth. In front of the spawning-chamber is another dam or bulk-head that raises the water several inches above the gravel before it flows over; the water falls from the spawning-chamber into an apartment below called a receiver, the water being kept at a proper level by still another and a movable bulk-head below. Above the latter bulk-head a screen is placed to prevent the escape of young fishes down the stream. In the spawning season the lower bulk-head and screen are to be removed, permitting ripe fish to ascend until they find the gravel-beds in the spawning-chamber, where they are allowed to deposit their ova undisturbed, and are then permitted to drop down the stream. The troughs are provided with perforated lids to keep the light from the eggs.

The flow of water is from an inlet below the spawning-beds, the water passing up through the gravel-bed so as to be filtered and cleansed before it comes in contact with the eggs. It falls from the spawning-chamber into the receiver, where the young fishes are kept until strong

enough to protect themselves in the stream below, when they are allowed to pass the screen into the open waters.

The advantages Mr. Furman claims for his invention are, protection of the eggs and fish from their natural enemies and from sedimentary deposit and freshets. It has not as yet come into very general use.

E.—FROG-CULTURE.

By Seth Green.

There are many stagnant pools about the country, useless in their present state, and, believing that they should be utilized, I cannot think of any better use for them than to make them into frog-ponds. I believe that the man who could raise a million frogs, and get them to market, would be a rich man. He will find many difficulties to overcome; but allowing him two years for experimenting, good results might be anticipated.

1.—HOW TO GET THE SPAWN.

Take a large dipper and go to the pond where the frog casts its spawn. You will find them in a glutinous bunch. When you dip them up, be very careful not to break the glutinous matter which binds them together. Put them in a pail or can, filled with water, and take them to your hatching-box, which is made after the fashion of the shad-hatching box. It is a box two feet long, eighteen inches wide, and a foot deep, covered on the bottom with gas-tarred wire sieving, twelve wires to the inch. Anchor the box in a gentle current. They will hatch in from seven to fifteen days, according to the temperature of the water.

2.—HOW TO TAKE CARE OF THEM.

Soon after they are hatched, they should be turned loose in a pond prepared with great care, as they have numerous enemies, such as fish, snakes, birds, lizards, coons, and many other animals. The pond should be made where the ground is springy, and have plenty of soft muck in the bottom. In this muck the frog lies during the winter. The pond should have a tight board fence, so that no animals could get in, and should be built so close to the water that no bird could stand on the ground inside the fence and pick up the polliwogs. If you do not heed all these precautions, and more too, your young fry will all disappear down the stomach of some bird or animal; and if you are not an unusually close observer, you will be in great wonder where they have gone.

You will have no trouble in feeding the young while they are polliwogs; nature has provided for that in all waters. They feed upon microscopic forms found in the sediment. In all waters not impregnated with injurious minerals these forms of life are numerous. Put the sedi-

ment under a strong magnifying-glass, and you will see that it is nearly all animal matter, or a formation between animal and vegetable, and is the proper food for the young frog-fry. They will eat it off from the sticks and stones on the bottom of the pond, and keep them as clean as if they had been washed. An old pond is better than a new one, because it will have more food in it.

The above is as far as I have gone. I have lost my polliwogs, and know what became of them, and hope others may profit by a knowledge of the difficulties in the way.

When they have reached the condition of frogs they live on all kinds of insects. To provide them food the only way is to procure insects in quantities large enough to support a great number of frogs. One plan I had was to put any kind of meat or anything that would call flies and place it around the edge of the pond and on floating boards; flies would come and cast their eggs, and the frogs live on the flies and maggots. I think they could be taught to eat meat. They would certainly eat it if they once tasted it. The question is, how to get them to taste it. I have many times tied a small piece of meat on a fine thread and attached the thread to a long fish-rod and moved it about near the frog's nose, and he would take it very quick. But you could not afford to teach a million in this way. I think there might be some plan invented to teach them to eat meat; any contrivance that would give it a life-like appearance and movement, and not have the fixture so clumsy that it would frighten the frog before he made a snap at the meat, would answer the purpose. The frog takes his food with a snap. Frogs are an article of food to a great many. They used to be plentiful, but are now very scarce, owing to their being taken during the spawning-season, which is the only time they are taken, except a few that are taken out of the muck in the springs where they gather during the winter.

APPENDIX E.

OBSTRUCTIONS

TO THE

UPWARD MOVEMENT OF FISHES IN STREAMS,

AND

THE REMEDY.

XXIII.—ON FISH-WAYS.

By Charles G. Atkins.

A—INTRODUCTORY REMARKS.

In the present paper, it is proposed to discuss devices for facilitating the progress of fish over dams in their *ascent* only. The question of their descent is by no means devoid of importance; but the difficulties and dangers attending this stage of their migrations are of a totally different kind from those that assail them on their ascent, and are to be met by a different set of expedients. Indeed, in most cases, neither the adult fish nor the young requires any sort of assistance in descending. If there is a sufficient body of water falling over the dam, they go with it safely and readily, tumbling down from great heights and rarely sustaining any injury. It is only where the peculiar configuration of the river and the dam or the scarcity of water leads them into dangerous rocks or mill-wheels that they require attention. The investigation of this branch of the subject is therefore of less pressing importance than that of the means of securing their ascent.

B—HABITS OF MIGRATORY FISHES.

Before discussing the mode of constructing fish-ways, it is necessary to consider briefly the habits and peculiar traits of the several species for whose use they are designed, so far as these habits and traits concern the present subject.

The only American species for which it has been thought expedient to build fish-ways are the salmon, shad, and alewife. All three of them ascend the rivers in spring and early summer in order to reach suitable places to deposit their eggs. The salmon comes both earlier and later than the other species, and proceeds immediately to the vicinity of its spawning-grounds on the upper waters, where it lies in quiet pools until the following autumn, its spawning-season. The shad comes while the river is still in full volume, later than the earliest, and earlier than the latest, run of salmon, and spawns within a short time of its arrival in some gently-flowing part of the river. It neither ascends so far nor pushes into so small streams as the salmon. The alewife, coming a little in advance of the shad, but largely in company with that species, spawns often in the still waters of gentle rivers, but more generally in lakes and

ponds from the largest to the smallest size, to reach which it will, when necessary, push up extremely small brooks.

It is a notable characteristic of all these migratory species to return, for the purpose of procreation, to the very waters where they themselves were born. Thus, each river, and, in general, each branch, each lake, and each pond, has its own army of migrating fishes, feeding and growing in the sea, and sending off each season a detachment to the parent-waters to continue the work of reproduction. The instinct that leads them into their native waters, though not strictly infallible, is so remarkably strong that those fishes that stray from the true way constitute a very small percentage of the whole army. Illustrations of this truth are to be found in many marked instances. The salmon of the Kennebec, where a small area of spawning-ground is still accessible, yearly pursue the course toward the upper waters of that river, so rarely turning off into the tributary, Androscoggin, that hundreds are caught in the former to one in the latter, though in natural fitness for salmon-breeding, aside from the facilities for ascending it, the Androscoggin is certainly not inferior. In a comparison of the Penobscot and Union, the case is stronger still. This established trait has an important bearing on the question of the ascent of migratory fishes past an obstruction that has been for generations impassable. Though known facts hardly warrant the conclusion that fishes will not often try to ascend to a higher point on the river than was reached by their parents, there is nothing to forbid the conclusion that they have less inclination to seek the higher waters than they would have had if they had been born there.

The behavior of these three kinds of fishes while in the vicinity of obstructions is found to correspond in some degree to the range of their migrations. Salmon and alewives, whose migrations extend to higher and smaller streams than those frequented by shad, are found to take more readily to narrow passage-ways than the latter.

Alewives are hardy, venturesome, little fish, following the main stream where it is practicable and easy, but ready enough to turn aside and seek a narrow way around a difficult point. They have been known to rush up a fish-way between the legs of the carpenter who was giving it the finishing strokes, and a trough only eight inches wide, divided into compartments, which were connected by passage-ways only four inches wide, has afforded ready passage to large numbers of them.* They exhibit a strong, gregarious instinct, moving in dense bodies as if by a common impulse. They always move over falls by day, and their favorite time is a bright sunny afternoon. On the approach of night, they drop back and rest in still pools until the next day is well advanced. So great is their inclination at night-fall to yield a little to the current that sometimes a large body of fish that has passed out of a fish-way just at dusk will settle back into it and rest in its bays, if they are easy enough, till

*Report of the Massachusetts Commissioners on Inland Fisheries, January, 1869, p. 6.

morning. In a fish-way without bays, I suppose they would pass down quite through it. Their movements, except in very difficult places, are always leisurely. At East Machias, when ascending the rapids below the fish-ways, they are generally several hours in accomplishing a distance which they are capable of doing in a few minutes. When occasion requires, they exhibit great agility and hardiness. They will turn on their sides and push themselves up a steep inclined plane against a sheet of water not half as thick as their bodies. Nevertheless they are ordinarily easily frightened, and one dip of a net or even the sight of a moving form will often drive them back from a fall or deter them from entering a fish-way.

Salmon are less inclined than alewives to leave the main current of a river, and their superior size and strength enable them to pass with comparative ease over falls that alewives would attempt in vain. It is commonly supposed that the scaling of a perpendicular fall of six or seven feet marks the limit of a salmon's power; but it is a well-attested fact that under favorable circumstances they have surmounted perpendicular falls of more than twice that height. A case in point is Carratunk Falls on the Kennebec, where the whole river rolls over a precipice into a gorge only about 60 feet wide. The height of the fall is 16½ feet, and it is as near perpendicular as the great volume of water and the narrowness of the gorge will admit. The depth of water at the foot of the fall is unknown; a pine log more than 50 feet long, going down endwise, disappears with great velocity, but is never heard to strike bottom, and when it re-appears, after a prolonged absence, it leaps nearly its whole length into the air. I have it from several trustworthy sources that many salmon have been seen to surmount these falls. They were observed in all the reported cases to leap through the air obliquely and strike the column of falling water at the height of 10 to 13 feet from its base, and swim from that point to the summit of the fall. Only those succeeded that struck the face of the fall with head straight against the current, and the majority of the leaps were unsuccessful. This feat would probably be impossible, were it not for the great depth of the water at the base of the fall, which affords sufficient space for the salmon to acquire a great momentum. In the pond at Bucksport, salmon have been seen to leap from still water 10 feet deep and clear a hedge 5½ feet high. In passing over low falls they rarely leap, but swim up in the sheet of falling water, which must have a considerable body to make the ascent possible, a thin sheet of water often causing the salmon to expose parts of his organs of locomotion to the air; an occurrence which sends him back to the foot of the fall. From what has been said to illustrate the strength and agility of the salmon, it is not to be inferred that they will pass all falls where it would be possible for them to do so. Leaping is something rarely observed, and it is quite likely that salmon hesitate long before attempting it, and that a large part of them will never attempt it. At the Augusta dam,

below which, in favorable seasons, some hundreds of salmon are caught' one is so rarely seen to leap, that I have never heard of an instance, and for a salmon to surmount it by swimming up the sheet that falls over it can hardly be thought possible.

Salmon move both by night and by day. It is generally assumed by European authorities that they will pass dams more readily by night than by day. It is the opinion of the Penobscot fishermen, however, that they rarely, if ever, attempt the passage of difficult places by night. In support of their opinion, they state that at Ayer's Falls, when it was customary to fish on the dam and in the passage-way now set apart for a fish-way with dip-nets, no salmon could be caught during the night; the drift-nets plied on the shallow rapids a short distance below being meanwhile quite successful. At daylight, however, fortune deserted the drift-nets, and from that time till the day was well advanced it rested with the dip-nets on the falls.

The shad, superior to the alewife in size and strength, is far inferior in courage. Timidity is one of its prominent characteristics. It is said to be frightened by the shadow of a bridge across its path. In a broad current it sometimes surmounts impetuous rapids, but I have never heard of its ascending a perpendicular fall, and it rarely ventures to follow up a small side-current, such as would suffice for the passage of salmon and alewives. So little success has attended the efforts to induce shad to ascend fish-ways, that in discussing most of the devices noticed in this paper they will be almost entirely left out of the account.

C—THE CONSTRUCTION AND LOCATION OF FISH-WAYS.

In the planning of a fish-way, there are several important things to be considered. The fish demand that it be accessible, attractive, and easy of ascent. The parties at whose expense it is built demand that it be durable and reasonably cheap. The owners of the water-power demand that it be not wasteful of water. To meet these various desiderata requires a careful consideration of the questions of location, capacity—form, material, and mode of construction. For our present purpose, however, it will be sufficient to discuss briefly the questions of accessibility, attractiveness, and ease of ascent, and then notice the principal devices by which it has been sought to attain them.

1.—SITUATION.

Accessibility may be set down as the first essential quality. To secure t, the foot of a fish-way must be so located that the fish will readily find it. Now, as has been before remarked, salmon, shad, and alewives all follow the main current of the river until they meet some obstruction sufficiently formidable to check their progress; at the base of this they swim many times back and forth, extending the search at each turn but a short distance down the shore on either hand. If there be no convenient pool at the base of the fall, they drop back occasionally to

pools farther down, but on starting afresh the chances are that they will again follow the main current, to be again baffled by the insurmountable fall. In this way they will repeatedly pass the mouth of a fish-way that opens into the main stream at some distance below the obstruction without noticing it, being attracted by the superior volume of the main river, while one whose entrance is in close proximity to the fall will soon be discovered.

The mode of securing an accessible location is sufficiently simple. It has been the general practice heretofore, in building ways for salmon and alewives, to place the upper end at the crest of the dam, or very near it. If the height to be overcome is very small, only a short fish-way is required, and it can generally be built for its whole length straight down the river, without carrying its lower end too far from the dam. But if a great length is required, the simplest way of avoiding difficulty is to turn the lower part of the fish-way at whatever angle may be required—even directly reversing it in many cases—and bring the lower end back to the vicinity of the dam. Thus, if the fish-way must be 350 feet long, it may be carried from its upper end 200 feet down stream and then brought back 150 feet, so that it will discharge its waters 50 feet from the dam. These reversed fish-ways have been built in many places, and this may be considered the most eligible form of Smith's, Foster's, and similar devices. In Pike's and Cail's spiral fish-ways, the same end is sought and attained by keeping the whole structure within a few feet of the dam, so that, on whichever side the water is discharged, it will always be sufficiently near the dam. In some cases it is practicable to place the upper end of the fish-way in a canal at such a distance below the dam that it may slope directly toward the latter and end near it. Such a location has been adopted in plans recently devised for a fish-way at Augusta, on the Kennebec. In devising a way for shad through the dam at Columbia, on the Susquehanna, the Pennsylvania commissioners deemed it essential that the foot of the fish-way should be no farther down the stream than the face of the dam, so that in searching for its entrance the shad should not be compelled to fall back at all, but should find it as a gap in the dam itself, in and above which the whole body of the fish-way was placed. So far as accessibility is concerned, such a location is perfect.

A fish-way may with propriety be located at either end of a dam which is built straight across the river and at right angles with its course, other things being equal; but it is always desirable to have it nearer to the strongest current and the main channel of approach. This desideratum cannot, however, always be secured; considerations of convenience and safety oftener dictating the location.

If the dam crosses the river obliquely, the best location is generally at the upper end, toward which the fish naturally tend as soon as they encounter the obstruction. This is illustrated by the success of the fish-way at Warren, on the Saint George, where both the obliquity of the

dam and the tendency of the current lead the fish directly to the fish-way.

It is sometimes the case that the approach to the dam from below is obstructed by a natural fall of sufficient difficulty to seriously impede the ascent of fish. Under these circumstances it is often admissible to place the mouth of the fish-way at a distance from the dam, which, under ordinary circumstances, would prove fatal to its success. Departure from the general rule is, however, to be taken only with extreme caution; since an error in this respect is often irremediable.

When from any cause it is impracticable to place the mouth of the fish-way in close proximity to the dam, it is sometimes practicable to turn the fish into it by a hurdle or other artificial obstruction placed across the stream. It would be better to place the hurdle obliquely; the mouth of the fish-way being at its upper end. Extensive contrivances of this sort cannot be maintained in our larger rivers, nor in those smaller ones where timber-refuse and other rubbish abound. A hurdle extending a short distance into the stream is frequently serviceable. One has been* devised to turn shad into the fish-way at Holyoke, on the Connecticut.

2.—ATTRACTIVENESS.

The second essential requisite in a fish-way is *attractiveness.* Fish must be invited to enter, and the only known means of extending such

* The following extract from a letter of Mr. J. W. Milner throws additional light on this subject. Speaking (from personal observation) of the Holyoke fish-way, he says: "The reverted portion of the fish-way faces the dam at the point where the sheet of water coming over the crest is the deepest, and where, of course, the most ample volume of water flows. At a high stage of water in the river, the cribs at the mouth of the fish-way are entirely submerged, and the outflow is directly into the face of the strong counter-current coming from the dam. The channel-way on this side next the fish-way is quite clear of rocks, and a free, ample volume of water flows unobstructed by the end of the fish-way, and, deflected by the wing-dam, turns outward until it has passed it. Outside of the channel-way are numerous large rocks and broken, foaming water. The shad seek the open channel-way in their passage up stream, and are led, in following it, close by the mouth of the fish-way; but, feeling the strong, fresh force of the current from the dam, they strike boldly into it, not in the least tempted by the weak current from the fish-way. Standing on the cribs above, I saw this happen day after day. Frequently as many as twenty shad in a school would pass up toward the dam, and they always quickened their movement as they felt the fresh flow of the water coming.

"There were two methods which I thought of for inducing the shad to enter: one was to continue the fish-way along the wing-dam, instead of turning it up stream, and then, by means of a low wing-dam placed a short distance above the mouth, turn a portion of the strong current into the cribs of the fish-way. For a short distance it would be well to take out the bulkheads, so as to make a guide-way to the beginning of the winding current of the ladder. The other method was, to open the side of the crib next to the wing-dam, and make the outlet in the upper compartment of the reverted portion. Heavy iron rods should then be set in the rock-bed of the river in the proper order, and a heavy netting stretched upon them, in the form of one side of the 'heart' of a pound-net, in this way utilizing a principle which the fishermen make so effective in exterminating the fish in aiding them to perpetuate their race and species."

an invitation, after securing a proper location, is to pour out a fair flood of water from the lower end of the fish-way. As has already been remarked, the migratory fishes prefer a large stream rather than a small one. Though any stream, issuing from the obstruction or near it, possesses the capacity to attract them to a certain extent, the attraction of the smaller is wholly or partially overcome by that of the larger stream. A fish-way may discharge a volume so small as to escape for many days the notice of the fish for whose use it was designed. So far as can be judged from its observed conduct, a fish is guided in its ascent of a river almost solely by the current, knowing little more than that its way is upward. When it meets the obstruction of a dam, there are several distinct currents beckoning it on; there are the currents from the waste-way, the mill-wheels, and the leaks, all competing with the current of the fish-way. It commonly chooses first the largest stream, and not learning rapidly from experience, nor early losing courage under repeated and constant failure, it may pass days in repeated ineffectual struggles against the impassable flood of the main stream, alternating with unsuccessful searches for an easier way. It is quite evident that the larger the volume flowing from the fish-way the sooner will the fish find and enter it. It is a reasonable proposition that this volume should bear some definite proportion to the total volume of the river, or to that part of it which passes down by the same channel into which the fish-way empties. The only attempt to fix such a ratio of which I am informed was made by Mr. Samuel U. Roberts in 1869. In discussing the construction of salmon-ladders in Ireland, Mr. Roberts laid down the following rules:

"The least quantity which will supply a salmon-ladder efficiently is that which will pass through an opening 8 inches wide, with a depth of 18 inches of water flowing through it, and the maximum quantity need not exceed that which will flow through an opening 3 feet wide with the same depth.

"I am of opinion that between these two limits a scale may be formed which will secure an adequate supply for salmon-ladders. It occurs to me that the fair basis on which to regulate the quantity is *the extent of the rain-basin of the river*, and I am of opinion that on all new weirs constructed on rivers, whether for navigation or mill-power purposes, the minimum opening to be provided should not be less than 8 inches in width, the sill being 18 inches below the apex or top of the weir; that the depth should be fixed in all cases at 18 inches, but that the width should increase in the following proportions: "When the rain-basin exceeds 50 square miles, the width to be increased at the rate of 1 inch for every additional 50 square miles until it amounts to 12 inches; when it exceeds 250 square miles, the width to be increased at the rate of 1 inch for every additional 100 square miles until it amounts to 18 inches. When it exceeds 850 square miles, the width to be increased at the rate of 1 inch for every additional 200 square

miles until it amounts to 3 feet, which may be fixed as the maximum breadth required."

In the paper from which this extract is made, Mr. Roberts instances three examples of successful fish-ways of the most approved pattern, and we may infer that his conclusions were drawn mainly from observations on their performance, which was certainly very satisfactory. Yet, if the size of the drainage-basin, or the volume of the river, be taken as a basis on which to fix the volume of water admitted to the fish-way, it is hard to see why the ratio between them should not be constant, or why the size of the fish-way should be limited while the size of the river continues to increase. It is quite probable that Mr. Roberts's maximum of 3 feet in width and 1½ feet in depth will be found insufficient for the passage-ways of fish-ways on our larger American rivers. The three examples given by Mr. Roberts are fish-ways on two Irish rivers, the largest of which, the Corrib, drains a basin of about 1,200 square miles, about the size of the basin of the Saint Croix. Between the Saint John and the Hudson are six or seven rivers with larger drainage-basins than that. The Kennebec drains 5,800 square miles; the Penobscot, 8,200; and the Connecticut, over 10,000. In point of volume, however, there does not appear to be so great a disparity. The Corrib discharges, during the summer-season, 120,000 cubic feet of water per minute, while the discharge of the Kennebec at Augusta is estimated at only 380,000 cubic feet per minute through the year;* being probably quite up to the average during May and June, when fish are ascending. The Connecticut, at Turner's Falls, in the winter of 1866, discharged at various times from 300,000 to 600,000 cubic feet per minute.† The comparison of these rivers with the Corrib is not complete without a statement of the peculiar way in which the water of the latter is used. Out of the 120,000 cubic feet flowing in summer past Galway, 100,000 are drawn away above the dam for the use of mills and navigation; only the remaining 20,000 flowing over the dam and down the main channel. Of this small residue, 720 cubic feet (being $\frac{1}{28}$) flow through the fish-way, the passage-ways of which are 2 feet square. Evidently, the salmon, having followed the main channel up to this dam, will much more readily find the fish-ways than they would if the entire volume of the river were pouring over the dam. Such will be the case in every river, and I think it quite plain, in view of these facts, that the size of the drainage-basin is not a safe basis on which to fix the size of the fish-way, but that the volume of water flowing over and through the dam, and the amount discharged from the mills in its immediate vicinity, must be considered in each individual case. The consideration of so many diverse circumstances will, of course, prevent the strict application of any rule; but it may, nevertheless, be instructive to observe the dimen-

* 200,000,000,000 cubic feet per annum.—The Water-Power of Maine, by Walter Wells, Superintendent Hydrographic Survey of Maine. Augusta: 1869, p. 91.

† Ibid, p. 106.

sions demanded in our large rivers by an application of the ratio that has been adopted in all successful fish-ways. All the successful fish-ways that have come to my knowledge have been built on small rivers, mainly, it should be stated, because their construction has rarely been attempted on large rivers, and because various unfavorable circumstances, such as a dearth of fish, have interfered with the testing of those that have been built. I do not think there is an instance of a tested fish-way for salmon and alewives on a river of larger size than the Saint Croix, which is, in drainage-basin, equal to the Corrib, in volume not much inferior, and has on its lower dam, at the head of the tide, a fish-way discharging about the same quantity of water as that at Galway, namely, 720 cubic feet per minute, which is about $\frac{1}{107}$ part of the average total volume of the Saint Croix. This fish-way has been fairly successful with alewives, great crowds of which have been seen passing through it, and it is presumed that salmon, when they could not surmount the dam itself, passed through the fish-way, considerable numbers of them being seen in the river above. The capacity of this fish-way may therefore be considered sufficient for its place.

To carry out the same ratio in the construction of a fish-way on the lower Penobscot, regarding for the moment only the total volume of the river, would require a capacity equal to the discharge of 5,133 cubic feet of water per minute, a volume which could hardly pass through an opening in a Smith or Foster fish-way less than two feet deep and twelve feet wide. Reverting now, for a moment, to the case of the Galway salmon-ladder, and recalling the peculiar features of its location, to which, perhaps, its success was largely owing, we note that the volume of water passing through it was $\frac{1}{28}$ that passing over the dam. To apply the same ratio on the Penobscot, we will assume that one-half the water is passing over the dam; the volume passing through the fish-way must then be about 6,700 cubic feet per minute, which would perhaps run through an opening two feet deep and sixteen feet wide. Thus, we find that if it is to conform in relative capacity to the tested fish-ways on the American river nearest approaching the size of the Penobscot, or to the best foreign salmon-ladder of whose performance I am informed, it must discharge either 5,100 or 6,700 cubic feet of water per minute, and this will probably require passage-ways two feet deep and twelve or sixteen feet wide. I am far from affirming that such a scale is essential; but it is worthy of notice that in building fish-ways with passage-ways only two or three feet wide on rivers of the size of the Penobscot, we are departing widely from the proportion heretofore found sufficient, reducing the relative volume, in fact, 70 or 90 per cent., and diminishing in an unknown ratio the chances of fish finding the entrance.

A large number, perhaps the majority, of the salmon-rivers of the Eastern United States are circumstanced like the Penobscot; half or more of the water at the fish-season passing over the dam. Others, among which the Merrimack at several points is a conspicuous example,

send the greater part of the water off into canals to feed mills. This circumstance, so far from being anything to regret, is of positive advantage, since it lessens the volume of water required in the fish-way.

Besides the necessity of a sufficient volume of water to attract fish into the fish-way, it must be deep enough and wide enough to afford them ample room for movement while ascending it. The latter desideratum may sometimes dictate the capacity of the structure in small streams; although, in rivers of considerable size, there can be no difficulty in this respect if due care is taken to meet the imperative demand for an *attractive discharge* of water. Salmon can, and sometimes will, pass through an opening much less than a foot square;* and if there be cases where so small an opening will discharge a flood duly attractive, these dimensions will suffice. Under the same limitations, the passage-ways of a fish-way designed for the use of alewives only may be reduced to six inches square, discharging not over 40 cubic feet of water per minute.

The dimensions given are adapted to the form of fish-way known as Smith's, and to those which, like it, afford a very free passage to the water. Of this kind are Foster's and the fish-ways in use in Maine rivers before his were introduced. Those devices which greatly retard the water, such as Brackett's, will require a corresponding enlargement of the openings.

In devising fish-ways for shad, an entirely different scale must be adopted. The lack of a sufficient volume of water is doubtless the prime reason why shad have never freely ascended any fish-ways, except the two remarkably wide ones constructed at Columbia on the Susquehanna River, which give passage to from 20,000 to 50,000 cubic feet of water per minute.

The wants of the fish alone fix the minimum capacity of the fish-way; but in determining the proper maximum, we must consult the interests of the owners of the water-power, who generally bear the burden of construction and maintenance, and who are therefore affected both by the cost of the structure and by the amount of water withdrawn by it from the use of the mills or canals. The cost, which is the most important point by far, will be considered in another place. Serious intrenchment on the water-supply is not likely to occur, for the following reasons: first, the amount of water required need not exceed one-fiftieth of the average volume of the river; secondly, the extensive use of the water for mills or navigation generally greatly reduces the volume passing over the dam and down the main channel by which the fish approach the fish-way, and warrants a corresponding reduction of the amount of water needed; thirdly, the period during which it is desirable to operate the fish-ways is at a date when there is generally an abundance of water in

* At Bucksport, salmon have passed in considerable numbers down through an opening eight inches wide and less than a foot deep in attempting to reach a spawning-ground in a brook.

the rivers, and a large amount going to waste, extensive milling-operations being rarely based on anything more than the *low run* of water.

3.—EASE OF ASCENT.

All the migratory fishes are capable of stemming a strong current. Were the fish-way a simple, straight sluice, so that the whole volume of water should pass through it without bend or break, a very high velocity would be permissible. Probably six or eight miles per hour would not be too swift. The Pennsylvania commissioners have erected a fish-way for shad of such a character, with a velocity whose maximum is estimated to be ten miles per hour.* This fish-way is over a dam only 5 feet high, and with a slope of 1 in 24. To construct a fish-way of this kind over a much higher dam would be impracticable, because with the same slope the velocity of the water would be accelerated in proportion to the increase of length, and would soon become excessive; and a more gentle slope would require a structure of too great size and cost. For economy's sake, both in respect to space and expense, it is deemed better to conduct the water down a steeper grade, (about 1 in 7, 10, or 15,) and correct the tendency to excessive velocity by repeated change of direction, which is generally effected, in the main, by numerous transverse partitions. Now, a column of water moving at the rate of ten miles per hour would acquire too great a momentum to admit of such control without breaking it up into a mass of tumbling spray, in which fishes would be utterly unable to direct their course. It is therefore necessary to greatly modify the velocity. In Brackett's fish-way it is brought down to the extremely low rate of about 100 feet per minute, which enables us to turn the water at right angles without breaking the surface. In Smith's and Foster's, it is twice as great. Probably the maximum permissible in any of the kindred styles is not above 250 feet per minute, or a little less than three miles per hour. Could a fish-way be devised with a grade of 1 in 10, in which the velocity should be greater without injuriously breaking the water, and should fish be found to ascend it as readily as in a more gentle current, it would have this important advantage over those employing a lower velocity, namely, it would discharge, in proportion to its size and cost, a greater amount of water, and would therefore be more attractive to fish.

In devising means for reducing the velocity of the water, I think too little weight has been given to the friction of the sides and bottom. Any one who will compare the motion of water in an ordinary stony brook, or a trench fish-way with that in a fish-way built of timber or cut stone, will be struck with the difference in the flow; in the former a much steeper grade can be introduced without producing a dangerous or unmanageable velocity. The cause of the difference is to be sought for in the conformation of the sides and bottom, particularly of the latter. In

* Report of the State [Pennsylvania] Commissioners of Fisheries for the year 1873. Harrisburg, 1874.

the brook, not only is the shore-line exceedingly irregular, but the bottom is, for the most part, formed of small bowlders, or, if of ledge, abounds in inequalities bristling with projections like a rasp, and acting on the water in a manner aptly likened to the action of the rasp on wood or metal. In the fish-way, great pains are commonly taken to have even surfaces. These, particularly when coated with slime, as they become after a while, are as smooth and slippery as glass, presenting a minimum of resistance to the descending water, which rushes across the parts with unchecked velocity against the partition-walls. It may therefore be of great service to give an artificial unevenness to the floor and sides of the fish-way. Large timbers crossing the floor at right angles to the current will be very efficient; but there is danger that at low stages of the water they may produce a succession of little cascades, to the great disadvantage of such fishes as alewives. Still, they may be introduced far enough apart to admit of sloping boards on the lower side. Another mode, applicable to both sides and floor, is to stud them with sawed strips of timber, say one or two inches in thickness and width, nailed on several inches apart at right angles to the current.*

A fish-way must be free from all such false or complicated currents as would mislead or perplex the fish. It is not to be supposed that they are guided by any knowledge of localities or directions, but simply by the downward motion of the water. To make head against the current is their steady aim, no matter whether it leads them directly forward or to right or left, so long as the turns in the course are not too sharp for their flexible bodies to follow. A path that appears very crooked to us may be straight enough to them, and is just as good as a straight path so long as it leads them constantly upward. In an eddy, the fish may go round and round in the same circle at a great expense of time, and a slight expense of strength too, but effecting nothing in progress. A similar waste of time and energy occurs in following up a side-current which is closed above by some impassable barrier. It is well known that in fish-ways consisting of series of pools, with narrow passage-ways from pool to pool, the greater part of each pool is occupied by a large eddy, wherein certain migratory fishes, notably alewives, collect in great numbers, and lie stemming the gentle current, or carelessly revolving with it, small numbers at each revolution leaving the main body and shooting up into the next pool above. It is not an easy matter to determine their motives in pausing so long in their upward journey. Experts entertain diverse views. The late N. W. Foster, when his attention was called to the matter, replied that such idling was in perfect keeping with the behavior of the fish when passing natural obstructions, and was not to be regarded as in any degree objectionable Others say that the fish do not know which way to go, and that they

* I am indebted for this suggestion to Mr. E. A. Brackett, of Massachusetts. I do not know whether the device has been tested, but it certainly appears to be a practicable mode of reducing the velocity.

sometimes lie there in perplexity, until, wearied by exertion, drunk and giddy from the continual whirling, they abandon the attempt and fall back out of the fish-way. That the fish will sometimes be so perplexed as to back out of the fish-way is sufficiently plausible to warrant the avoidance of the causes that lead to it, even at considerable cost. It is also quite likely that fishes, like other creatures, are capable of being made dizzy by continual whirling; but I can hardly think it possible that this ever occurs in the pools of any well-proportioned fish-way of any of the styles that have been in vogue in the United States during the last ten years. Nor does it appear likely that the expenditure of strength in stemming eddies is ever sufficient to be of great moment. The loss of time, however, is a serious matter. While in a fish-way, as well as below any barrier, fish are liable to be turned back by fright, or, in the case of alewives, by the approach of night, and delayed perhaps for many days in their journey, and exposed so much longer to the various mischances that beset them. The quicker, therefore, they can be got through the fish-way and past the obstruction the better.

It was formerly supposed that fishes required frequent opportunities for rest, and no plan was thought complete which did not include a number of pools for that purpose. The general tendency of the results of more recent study is to the conclusion that no such resting places are necessary; the fishes being capable of long-continued exertion, and accomplishing the ascent with much greater speed and certainty when kept close at their task than when allowed to idle along in pools and eddies.

Thus it appears that eddies are of no value as resting-places, because they are not needed, and that they are probably, to a certain extent, positively injurious by delaying the advance of the fish. They may therefore be dispensed with, not only without detriment but probably with advantage. Taking this view of the case, our aim will be to produce a simple and uniform flow of water. Perfection in these respects is neither practicable, nor, as many instances prove, necessary. There are not wanting instances of fish-ways with large and strong eddies that worked admirably; and even in the best elaborated fish-way that has yet been introduced, the eddying and swirling of the water is not entirely obviated.

D—DEVICES WHICH ARE IN USE OR HAVE BEEN PROPOSED.

Fish-ways may be classified with reference either to their details or their general arrangement.

With reference to details they may be grouped thus:

Gap.

Trench, ditch, or "Cape Cod" fish-way.

Oblique groove:

1. Single groove.
2. Brewer's.

Step:

1. Box or "pool" fish-ways:
   (*a*) Overflowing, (old style.)
   (*b*) With passage-way cut down to floor, (Smith's.)
   (*c*) With passage-way submerged, (Cail's.)
2. With contracting galleries, (Pike's.)
3. With transverse sloping floors, (Steck's.)

Inclined plane, without steps:

1. Plain, (Pennsylvania.)
2. With partitions at right angles:
   (*a*) Common style, ("rectangular compartment.")
   (*b*) Brackett's.
3. With oblique partitions:
   (*a*) Foster's.
   b) Swazey's.

With reference to general arrangement they may be again classified thus:

1. Extended.
2. Reversed.

These two forms have been applied to most of the step and inclined-plane fish-ways, and can be adopted with any of them.

3. Spiral, (Cail's; Pike's, &c.)

This form is an essential feature of Pike's, and may be combined with the details of most of the step and inclined-plane fish-ways.

1.—GAP.

The simplest form of fish-way is a gap in the dam. This appears to have been much in use in British rivers, where it receives the name of "Queen's gap." In low dams, it answers well for salmon. In America, it has occasionally been resorted to for alewives; and in dams built of plank, it can be made by the simple removal of one or two perpendicular planks, forming an opening quite to the bottom of the stream, and, if circumstances be favorable and the height be not great, it works well and saves the expense of a permanent structure. The only instance of a permanent gap-fish-way that I have seen is at Milltown, on the Saint Croix, where wing-dams are built from either shore obliquely up the stream, and separated at their upper ends by a space several feet wide. Where circumstances permit a dam to be built in this way, it forms the best fish-way that could be devised.

4.—TRENCH, OR CAPE COD FISH-WAY.

When a dam is too high to admit of the use of the gap, a more elaborate contrivance is necessary. The rudest, and in some cases the easiest to build, is what may be styled the trench-fish-way, in which a sufficient stream of water is conducted around the dam over the ground, in a

trench or in a natural crevice or ravine, the velocity of its flow being moderated by the unevenness of the bottom and sides, by turns in its direction, or by rude walls of stone, crossing it at convenient points. It commonly assumes the form of a series of pools, gently flowing or eddying, connected by short runs of swift water. In operation, it is when well located, very successful, and being at the same time cheap, is perhaps to be preferred to any other form, where the facilities exist for its construction, and there is no special reason to grudge the extra volume of water that it requires over the more artificial kinds. A good many fish-ways of this form have been in use in New England. In Massachusetts it has received the name of "Cape Cod fish-way." In Maine the most notable is at Damariscotta Falls. Damariscotta River is frequented by alewives, affording no suitable breeding-grounds for salmon or shad. Tradition says that in its natural state not even alewives entered it in any greater numbers than might be supposed to straggle in from the neighboring Pemaquid river. They could not surmount the fall, which is about fifty feet high, rushing down over a rugged ledge. About 1806 the inhabitants built a fish-way, consisting of 20 or 30 pools, in a crevice of the ledge. The alewives rapidly increased, and have yielded large annual returns down to the present time. A few years since the catch was estimated at 1,200,000, which was said to be considerably below the former yield. There are several places in this fish-way that are more difficult for the fish to ascend than any Foster fish-way that I ever saw, yet it seems to meet the wants of the alewives.

At Brooksville, Me., there is a trench-fish-way around a dam 18 feet high, which has a pretty steep grade, without pools or considerable bends, yet it is quite effective. Alewives are the only fish ascending it, and they accomplish the ascent without difficulty.

3.—OBLIQUE GROOVE.

The single oblique groove leading in a straight line down the face of a dam from its apex to the water below has been tried in the British islands and found utterly useless. Its faults are thus described by Mr. Samuel U. Roberts, of Galway, Ireland:

"The velocity of the water which enters the groove at the apex of the weir increases in its descent down the inclined plane of the groove, its depth becomes proportionately diminished, and it is utterly impossible that any salmon can pass up it. It is true that when water is flowing over the apex of the weir, additional water will be gathered in the groove, where it is formed diagonally across the apron of the weir; but this water enters the groove at *one side only*, and the fish is compelled to swim against the current diagonally, which is unnatural. Any large quantity of water discharged over the apex of the weir will sweep fish out of the groove; while in dry weather, the thin, rapid stream of water on the lower portion of the groove will render it impossible for any fish to ascend."

The two devices patented by J. D. Brewer, (Plate XXII, fig. 6, first device; Plate XXXII, same in operation; Plate XXXIII, second device,) of Pennsylvania, are combinations of oblique grooves sunk in an inclined plane, and conducting streams of water in a zigzag course down to the water below. The first* provides for a single simple stream, turned by very sharp angles. In the second, the stream is divided at regular distances into two, which, after running out to the opposite sides of the fish-way, are brought again together in the center. Both are designed to be used at various stages of water, even when a considerable volume is pouring over them. In the latter case, the tendency will be toward a violent rotary motion in the grooves; and at all stages of water there is danger of the velocity of the current and the violent boiling of the angles being too hard for fish to encounter.

4.—STEP-FISH-WAYS.

The peculiarity of all the devices grouped under this head is a level floor to each division of the fish-way, the descent being accomplished by a succession of falls or steps. The common form of the divisions is nearly square, but in Steck's and Pike's they are long and narrow. What is commonly known as the old "pool" fish-way (Plate XXII, Fig. 4) consists of a number of boxes, placed in a series below the apex of the dam in such a way that the water pours over the top of each box into the next below it in a succession of cascades. The width of the sheet is equal to the length of one whole side of a box. This device has been tried in various British rivers, but has proved unsatisfactory. In America it has been tried, and, wherever tested, found radically defective. When the water is high, its motion in the boxes becomes so violent that no fish can stay

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* *Brewer's Improvement in Chutes and Fish-ways.—United States Patent-Office.—James D. Brewer, of Muncy.*

(Specification forming part of letters-patent No. 126257, dated April 30, 1872.)

To all whom it may concern:

Be it known that I, James D. Brewer, of Muncy, in the county of Lycoming, and State of Pennsylvania, have invented certain new and useful improvements in chutes for the passage of fish; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawing and to the letters of reference marked thereon, which form a part of this specification.

The nature of my invention consists in a series of isosceles or equilateral triangles extending from the opposite side-walls of the chute of a dam, and laid in the bottom thereof so as to form a zigzag course, and leaving an open space for the passage of fish up and down said chute.

In order to enable others skilled in the art to which my invention appertains to make and use the same, I will now proceed to describe its construction and operation, referring to the annexed drawing, in which is represented a perspective of my chute.

A represents the bottom, and B B the side-walls of the chute of a dam. On the bottom A, and extending from the side walls B B, are laid a series of isosceles or equilateral triangles, C C, forming a zigzag course, and leaving an open space, *a*, of about twelve inches wide, more or less, for the passage of the fish up and down the chute. The triangles C C are laid on two stringers, which extend up and down the chute, and

in them a moment, and with low water the sheet pouring over the rim of each box is so thin as to deter fish from attempting the passage. To leap from box to box would be easy enough for salmon and not beyond the power of alewives, but neither of these fishes is *willing* to leap an obstruction. Probably salmon never leap a fall until all other means of passing have been tried many times in vain, and perhaps, as has been before remarked, many of them will never leap. The fish-way built at Lowell, on the Merrimack, in 1866, was after the box-pattern, arranged very nearly as in the illustration of the box fish-way. It was very solidly built, with boxes about twelve feet square. Its location was such that the amount of water entering it could not be regulated, and consequently it was frequently useless, either from floods or drought. At another place in Massachusetts a fish-way of this kind was fairly tested in the presence of a multitude of alewives. "At the Mystic Water-Power Company's dam in West Medford," say the Massachusetts commissioners,* "was a step-fish-way, consisting of a number of deep boxes, each communicating with that above by a little fall. Nothing could be easier than this ascent. The alewives swarmed in thousands at the foot of the dam. A few would jump the first and second, and even the third fall. Beyond this not one would go; nay, they would turn about and come down again."

5.—SMITH'S FISH-WAY.

Poor as the "pool" fish-way is, it is easily altered into a very efficient form. It is only necessary to cut a narrow passage through the wall

the triangles are secured to said stringers by means of iron bolts or clamps. The triangles and bottom of the chute are to be paved with stone or other suitable material.

By means of this arrangement, fish are enabled to pass up streams obstructed by dams or slight vertical falls, or natural vertical obstructions, when not too elevated.

In addition to this, it will be found that water running through a chute of this kind will have a tendency to keep crafts descending the chute in the center, and thus secure to them a safer passage in their descent. In the present chutes, the force of water confined in a narrow space has a tendency to raise in the middle, and thus throw a raft or ark or other craft out of the center to one side or other, and sometimes obliquely across the chute. It also breaks the force of the water, and thus protects the bottom of the chutes, and will have a tendency to prevent them from bursting up or being washed out and forming breakers, so destructive to lumber-rafts and even the lives of watermen.

I am aware of the existence of Daniel Steck's patent of June 26, 1866, and do not claim anything contained therein; but—

What I do claim, and desire to secure by letters patent, is—

A series of isosceles or equilateral triangles, extending from the opposite side-walls of the chute of a dam, and laid and secured in the bottom thereof, substantially in the manner and for the purposes herein set forth.

In testimony that I claim the foregoing as my own I affix my signature in the presence of two witnesses.

JAMES D. BREWER.

Witnesses:

WM. BRINDLE.

J. M. M. GERNERD.

* Report of the [Massachusetts] Commissioners of Fisheries for the year ending January 1, 1870, p. 4.

which separates pool from pool for the water to flow through, instead of pouring over the top of the wall, and we have a device by which salmon and other fish can pass from the bottom to the top by swimming instead of leaping. This improvement was made in Scotland about 1840, by Mr. James Smith, of Deanstone. His fish-way appears to have had compartments, or pools, nearly square, two or three feet deep, with level floors, a step from each pool to the next, and passages about one-fifth the width of the pools, opened at opposite corners. This form was remarkably successful, and became the means of repeopling many rivers.

The salmon-ladder at Galway, on the river Corrib, (Plate XXII, Fig. 1; Plate XXVII, Fig. 1,) perhaps the most successful known, is constructed after this pattern. The weir crosses the river obliquely, is only 5 feet high, but quite impassable. The fish-way is located at its upper angle, is 46 feet long, divided into five pools nearly 10 feet square, which are connected by narrow passes; the inlet is two feet square, and the average depth of water in the pools is 14 inches. The volume of water flowing down the river Corrib, at Galway, during the summer, is 120,000 cubic feet per minute. Of this total, 100,000 cubic feet are led off to the mills and canals, 19,280 cubic feet pass over the dam, and 720 cubic feet per minute pass through the fish-way, which thus consumes $\frac{1}{160}$ of the total volume of the river, and about $\frac{1}{28}$ of the amount that passes to waste down the main channel. In 1853, the year when this fish-way was first opened, the catch of salmon in the river was only 1,603. In 1864, it had risen to 20,512. The latter year 40,000 salmon are estimated to have passed up through the fish-way. Mr. Roberts says, "It is not unusual to count the salmon passing up at the rate of 140 or 150 per hour, and I have no doubt but that at night they ascend in much larger numbers."*

Two other successful Smith fish-ways exist at Ballysodare (Plate XXVII, Fig. 2) and Collooney, in the county of Sligo, Ireland. Both of them, being very long, are reversed, so that the lower end in each case is brought close to the fall. At Ballysodare, the fall is 19¼ feet; the fish-way is 174 feet long, divided into 15 pools, each of which is 10 feet wide and 11 feet long, with an inlet 10 inches wide and 2½ feet deep in ordinary. The fish-way at Collooney closely resembles the above. The obstructions on this river were natural and precipitous, and shut salmon out of the river completely. After the ways were built, salmon ascended freely, in very small numbers at first, but increasing so fast, that eleven years later 10,000 were caught in a single season. The Smith fish-way is undoubtedly good enough for salmon; it is, perhaps, liable to be difficult for alewives, but the addition of a slope, instead of an abrupt fall at each step, would go far toward making it easy for them.

6.—CAIL'S FISH-WAY.

This is a recent invention of Mr. Richard Cail, mayor of Newcastle-on-Tyne, England. It differs from Smith's in having the passes entirely

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*Fourth report of the Commissioner of Fisheries of the State of Maine for the year 1870, p. 41. (See illustration.)

submerged, opening 12 or 14 inches square at the bottom of each pool, and midway of its width instead of at one side. The inlet is made larger than any of the subsequent passages, so that the pools are kept full. The dimensions adopted by Mr. Cail are as follows: Pools at least 6 feet square; bottom of first pool 4 feet below the crest of the dam; each of the subsequent pools successively 18 inches lower than the one that precedes it; inlet 14 inches square; other passages 12 inches square. With pools 3 feet deep the passes are nearly 2 feet under water. The theory of the inventor is that the water in each pool acts as a cushion to the inflowing column, retarding its velocity sufficiently for practical purposes. This device* has been tried at Dinsdale, and pronounced successful with salmon. Judging merely from the plans and descriptions, it does not appear to have any advantage over Smith's and similar contrivances. Though fully satisfactory with salmon, its success with alewives would be doubtful.

7.—PIKE'S FISH-WAY.

This (Plate XXIX, fig. 1, perspective view; fig. 2, ground-plan) is the invention of Robert G. Pike, esq., of the board of commissioners on inland-fisheries of the State of Connecticut. It differs from any yet described in having long, narrow galleries instead of short pools. The floors are level, and the descent accomplished by easy steps of 3 inches each. The velocity of the current is checked by change of direction and by the convergence of the sides of the galleries. For the sake of economy in space and material, the galleries are built side by side, without waste-space, and arranged in a sort of spiral. In regard to dimensions, Mr. Pike writes as follows:

"I propose to build fish-ways upon this plan, (for falls of 3 to 8 feet height,) with passage-ways 2½ feet wide, narrowing to 18 inches; the sides to be 2 feet or 30 inches high, and the fall not *less* than 1 in 25 or 30. The saving of material in this form of fish-way is not far from 35 per cent., to say nothing of the extensive masonry and cob-work usually required in long fish-ways."

"In making one circuit of a fish-way of the above dimensions, the water traverses 7 galleries, having a total length of 68 feet, and falls over 14 steps of 3 inches each, which gives it a total fall of 3½ feet to each circuit. Having reached the end of the circuit, the water passes *under* the point of beginning, and pursues its course through a second circuit, which is precisely like the first. Between the several floors of the spiral there is thus a space of 3½ feet, of which about one foot can be left open in the outer walls for the admission of light. The inner galleries are lighted by smaller apertures. The compactness, economy, and easy grade attained by this device are remarkable, and I think entitle it to be considered the most valuable contribution to the science of fish-ways since the invention of Smith."

* See illustration.

8.—STECK'S FISH-WAY.

The invention of Daniel Steck, (Plate XXII, fig. 2,) of Pennsylvania, differs from Smith's in having the partition-walls placed very near together, giving long and narrow pools running across the fish-way, and in having the floor of each pool slope upward from the entrance to the outlet. The advantages of this plan are, first, that it enables the builder to accomplish the descent in a much shorter distance, thus bringing the foot of the fish-way nearer the dam; and, secondly, that it avoids eddies, the pools being too narrow to permit them. The disadvantages are that it requires the occupancy of a great breadth of the dam, and that, when the supply of water is scanty, the fall at each step will be an impediment to fish.

9.—INCLINED-PLANE FISH-WAYS.

The fundamental distinction of these from the step-fish-ways is that the descent is accomplished by a general inclination of the floor instead of steps. The fish-ways of this class requiring notice are the Pennsylvania style, the common rectangular, Brackett's, Foster's, and Swazey's. All except the first named are built with compartments to check the velocity of the current.

10.—THE PENNSYLVANIA FISH-WAYS.

These are two structures built by the State of Pennsylvania in the dam at Columbia on the Susquehanna River. They are both perfectly plain open sluices, entirely beyond precedent in dimensions and ease of grade, and distinguished from all the common styles by being located in and above the dam, instead of projecting in front of it, so that to the ascending fish the entrance to the fish-way appears as a simple gap in the dam.

The first (Plate XX, fig. 3, plan in outline; fig. 4, profile in same) was built in 1866, at a point 1,500 feet from the right bank of the river; the total length of the dam being 6,800 feet, and the height of the fall about 6 feet. The fish-way is 45 feet long, 20 feet wide at the upper end, and 40 feet wide at the lower end. The widening of the floor is effected by offsets, with the design of affording resting-places for fish; (this feature was omitted from the later plan.) The grade is 1 in 15. The outlet is on a line with the face of the dam. Both fish-way and dam are of heavy crib-work, filled with stone and furnace-cinder.

Uncertainty existing as to the success of this structure, a still larger one (Plate XX, fig. 1, plan in outline; fig. 2, profile in same) was built in 1873, at a point 2,500 feet from the left bank, where it was thought that shad congregated when stopped by the dam. The new fish-way is of a uniform width of 60 feet, is 120 feet long, and has a grade of 1 in 35. Colonel James Worral, the engineer who designed both fish-ways, estimates the velocity of the current in this one to be less than 10 miles per hour.

The large size of these fish-ways is demanded by the peculiar character of the shad, for the use of which they are designed. They are of too costly a character to be used on high dams, even if it were possible to conduct a body of water down a long open plane like this without the attainment of too great velocity. The fish-way of 1866 may have given passage to some shad, but has not met the expectations of its builders. That of 1873 has had one season's trial without fully establishing the fact of its success.

11.—THE COMMON RECTANGULAR FISH-WAY.

This (Plate XXXI, in operation) is apparently the original style of the inclined-plane fish-way. The partitions are run at right angles with the sides of the fish-way, making rectangular compartments, (commonly square,) with passage-ways one-eighth or one-fourth the width of the fish-way, cut quite down to the floor, and placed alternately against the right and the left side. This is very closely like Smith's in form and action, being in the latter respect almost identical when well supplied with water. In case of a scanty supply of water, the advantage is with the inclined plane, particularly for such fish as alewives. This device was in common use in the eastern part of Maine for many years previous to Mr. Foster's improvements, which were made about 20 years ago, and is probably of as early origin as Smith's. When well proportioned and located, it is very successful with both salmon and alewives. Among the various modifications introduced, the following deserve notice:

First, to avoid the violent swirling of the water, which takes place when the floor is an interrupted plane, the bottom of each passage-way is blocked up a certain distance above the floor, resulting in an increase of the depth of water in the compartments without increasing the volume flowing, and making a perpendicular fall at each passage-way. In the latter result lies the only disadvantage, and this can be overcome by placing against the lower side of the blocking an inclined plane, which shall support the descending body of water. It should be remarked that the blocking of the passage-ways turns the structure into a step-fish-way, and that the same mode of overcoming the difficulty of the perpendicular fall may be applied to any step-fish-way.

Secondly, to check the force of the water across the pool, and thereby prevent a difficult cross-current in the passage-way, an arm is attached to the upper side of each partition-wall and at right angles with it. This modification has been many years in use at Warren on the Saint George River.

Thirdly, to avoid the large eddies and accompanying waste of space caused by the large compartments, the partitions are placed nearer together. When the distance between the partitions is equal to the width of the passage-ways, the latter being, say, one-third or one-fourth the width of the fish-way, eddies are almost wholly avoided, and the economy of space is so great that a grade much steeper than ordinary can be adopted. A combination of this and the first modification is strongly recommended.

12.—BRACKETT'S FISH-WAY.

Invented and patented by E. A. Brackett,* (Plate XXI, fig. 6, plan; Plate XXII, fig. 5, illustration for patent; Plate XXIII, fig. 1, plan of fish-way at South Hadley Falls, Mass.; fig. 2, elevation of same; Plate XXV, plan of fish-way at Brownville, Me.; Plate XXVIII, perspective view,) of the board of commissioners on inland-fisheries of Massachusetts. The distinctive features of this fish-way are the form and arrangement of the partitions and arms, in the device of which the moderation of the velocity of the current has been the main thing aimed at. The most complete success has been attained. The water flows very gently, without breaking or forming strong eddies; and alewives and other fishes ascend it with the utmost ease, passing almost without hesitation through its whole length. Fish-ways of this pattern have been introduced very extensively in Massachusetts and several other New England States. When salmon are the only fish to use it, a very steep grade, say 1 in 6 or 7, could probably be adopted to advantage; but as ordinarily built, in alewife-rivers, the grade adopted is about 1 in 10. The style of arrangement will be readily understood from the illustrations.

**Brackett's improvement in fish-ways.—United States Patent-Office.—Edward A. Brackett, of Winchester, Mass.*

(Specification forming part of letters-patent No. 132349, dated October 22, 1872.)

To all whom it may concern:

Be it known that I, Edward A. Brackett, of Winchester, in the county of Middlesex, and commonwealth of Massachusetts, have invented certain improvements in fish-ways, of which the following is a specification:

The nature and purposes of a fish-way, so called, are, as is well known, to enable fish to overcome the obstacles of a dam and to ascend streams which would otherwise be inaccessible; and the primary object of this invention is to provide a means whereby the otherwise rapid current of the fish-way may be reduced to a sluggish stream of uniform or practically uniform speed throughout, whereby fish may ascend or descend, or rest at their leisure. My improvements consist, first, in extending a fish-way up stream through a dam, and so as to extend some distance above the latter, and in providing said fish-way above the dam with a series of water-inlet ports of various heights in order to accommodate the various stages of water and avoid the great pressure which would otherwise result from high water or a flood; and, secondly, the nature of these improvements consists in the construction of the trough or chute of a fish-way by means of an oppositely-arranged series of abutments or bulk-heads, or their equivalents, whereby the original current is diverted into a circuitous or sinuous course, and a series of eddies produced, which retard the speed of said current to any desired extent, substantially as hereinafter stated.

In the drawing [Plate XXII, fig. 5] accompanying this specification, I have represented, in Fig. 1, a vertical section; in Fig. 2, a side-elevation; and, in Fig. 3, a plan of my improved "fish-way."

In these drawings, A is supposed to represent the location of the dam of a river or stream into which a fish-way is to be introduced.

In carrying out the purpose of my invention, I provide a rectangular oblong trough, or box, B, closed at the sides and ends, with the exception of one or more water-discharge ports, *a*, at its lower or down-stream end, and several water-inlet or supply

13.—FISH-WAYS WITH OBLIQUE PARTITIONS.

Foster's improvement (Plate XXI, fig. 3, plan; fig. 4, same, modified as built on Penmaquan River, Maine; Plate XXIV, fig. 1, location of fish-way at Union Mills, Saint Croix River; fig. 2, plan of same; fig. 3, side-elevation of same; fig. 4, cross-section showing shape of passage-ways; Plate XXX, fish-way closed) consisted in oblique partitions crossing

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ports, *b*, b^1, b^2, &c.; at its upper end, the trough or box being placed within the stream in a sloping position and projecting through and extending somewhat above the dam, as shown in the drawing; the slope of the said trough or box being varied with circumstances, the character of the stream, and the velocity to be imparted to the current passing through it. The inlet-ports *b*, b^1, b^2, before named, are placed at different points, up and down, of the stream, and consequently admit water to the trough at different altitudes; the port *b* being the highest and receiving the water at the high stage, and the port b^2 being the lowest of the series and receiving water when it will not enter the upper one.

Having thus seen how I control and regulate the admission of water to the chute B, I will now explain how I guide its course through the same, and in so doing carry out the primary object of my invention—that of retarding artificially the rapidity of the current. To this end I dispose within the chute or box A, and generally throughout its length, a series of abutments, *d*, *d*, *d*, &c., disposed at regular or irregular distance asunder and extending partially across the width of the chute, the abutment of one side being disposed opposite the recess formed by the two opposite adjacent abutments. The abutments *d* are not limited in number nor arbitrarily in position, but are arranged substantially as stated. Each abutment, or deflector, *d*, is formed with one or more bends or wings, *e*, *f*, &c., which extend longitudinally or thereabouts of the length of the chute, in order that the current of water intercepted by the abutment shall be compelled to take an upward or return movement for a short distance before passing to the next ensuing abutment to be again intercepted and diverted. In this manner, the current of water entering the head of the chute is continually interrupted and diverted from a direct course, a series of eddies being the result, following each other in such rapid succession as to retard the current throughout the entire chute. As the only headway the water can attain is in passing from one abutment, or deflector, to another, and as these may be so near to each other as to almost entirely reduce the stream to a continuous series of eddies, the water makes its exit from the chute at about the same velocity with which it courses through the upper part thereof, and this velocity may, of course, be increased or diminished, according to the number of deflectors.

In a chute, or fish-way, constructed essentially as above described, the fish encounter very little resistance to their passage, and the eddies allow them to remain at rest at any time. In fact, in fish-ways now in actual use on this principle, thousands of fish are found in the proper season to be both ascending and descending the chute at the same time.

Claims.

1. In a fish-way which is extended through the dam of a water-course and some distance above the same, as described, I claim the ports *b*, b^1, b^2, arranged substantially as shown, whereby the water is admitted through one or more, according to conditions in its height, as set forth.

2. In a fish-way provided with a series of deflectors, *d*, for causing the water to take a sinuous course through the same, I claim the wings *e*, *f*, formed on or attached to said deflectors, substantially as and for the purposes herein set forth.

E. A. BRACKETT.

Witnesses:

W. E. BOARDMAN.
E. G. PINKHAM.

the fish-way completely, as in the rectangular style, with a passage-way at the upper end of each partition, on alternate sides of the fish-way. This was at first thought to be an important improvement, but is now regarded with less favor. Its action does not differ greatly from that of the common rectangular fish-way, while the obliquity of the partitions interferes with the introduction of arms like those in Brackett's and some other styles, and with its adaptation to the reversed and spiral arrangements. A good many of these have been built in Maine, and quite a number are now in successful operation.

A better device than Foster's is one recently invented (Plate XXI, fig. 1, plan; fig. 2, same, with additions, by C. G. Atkins) by Mr. Alfred Swazey, of Bucksport, Me., in which the passage-ways are all near the center of the fish-way, but discharge the water into two series of pockets arranged on each side. The movement of the water in a model four feet wide is admirable.

14.—GENERAL ARRANGEMENT.

Of the three modes of general arrangement mentioned above, namely, the *extended*, the *reversed*, and the *spiral*, the first being the simplest, has been most generally adopted. The disadvantages attending it have been considered sufficiently under the head of *location*. Though on low dams and in exceptional cases it proves quite satisfactory, it is utterly unfitted for the majority of cases; and to its use in locations where it carries the mouth of the fish-way to a great distance from the dam, I attribute a large share of the failures that have occurred.

The *reversed* form is far superior to the extended when applicable, as it generally is. Considering only the question of its adaptation to the requirements of the fish, it is fully equal to the spiral. But when the questions of economy of space and material are brought into consideration, it is found that the reversed form has no advantage over the extended, and that both these are far inferior in these respects to the spiral, which is the *ne plus ultra* of fish-ways.

The spiral form may be given to almost any of the step and inclined-plane fish-ways, but to some with greater facility than others. The easiest to adapt are the rectangular plans, such as Smith's, Cail's, Brackett's, and the common rectangular. So far as I know, only three styles of spirals have thus far been devised, namely, Pike's, Cail's, and an adaptation of the rectangular-compartment fish-way. Pike's is originally and essentially of this form. It is described above among the step-fish-ways, and illustrated in plan and perspective, (Plate XXIX, figs. 1 and 2.) Cail's spiral* is an adaptation of his step-fish-way described above. Each circuit consists of 4 pools, arranged in a large square; the descent from pool to pool being 18 inches, a descent of 6 feet is accomplished in a single circuit. The dimensions proposed by Mr. Cail (for small rivers, I suppose) are as follows: pools, 6 feet square and 3 feet deep; inlet, 14 inches square;

* See illustration.

passes, 12 inches square. The spiral arrangement occupies an area on the ground of only 12 feet square. This, it should be repeated, is not fitted for use in alewife-rivers. The third style of spiral referred to is an adaptation of the common rectangular,* devised by myself for several dams on the Presumpscot and Machias Rivers. It may be described as a series of reversed fish-ways, piled one on another; the two arms of a reversed fish-way constituting a circuit. By running forward 15 feet, reversing, and running back the same distance, we accomplish a descent of 3 feet, which enables us to repeat the circuit immediately under the first floor. Thus, whatever the height of the dam, the area occupied by the fish-way is no larger than for one only 3 feet high.

A similar statement might be made in reference to other styles of spirals. The saving in ground-area over the extended and reversed arrangements is, therefore, for a dam 6 feet high, one-half; for a dam 9 feet high, two-thirds; for a dam 12 feet high, three-fourths, and so on. This saving frequently enables us to occupy a very eligible site, which would be too small for any form but the spiral. The economy of material is not so remarkable, but still it is a very important item. Mr. Pike estimates the saving in his form to be 35 per cent.

The advantage of the spiral with reference to the location of the outlet (or lower end) has already been alluded to. There is little danger of getting it too far from the dam, on whatever side the water be discharged. Still there will in most cases be a choice in favor of this or that side, according to the peculiar features of the site.

E—SUBSIDIARY CONSIDERATIONS.

1.—PROTECTION AGAINST FLOODS.

The most of our rivers are subject to destructive floods, which, besides the force of the water, assail all exposed structures with floating ice and logs. It is, of course, essential that a fish-way be shielded from dangers of this sort. The first aim should be to select a site where protection is already secured. Frequently, however, it is necessary to place the fish-way in the open river. It may then be protected by a pier, or, if that be impracticable, a narrow fish-way can be covered with stout plank so that floods may sweep over it without injury. As the latter plan involves the entire abandonment of all attempts to regulate the supply of water in the fish-way while the flood continues, it should not be resorted to when it is practicable to secure a position that admits of constant access and regulation.

2.—MATERIAL AND COST.

Little need be said in respect to material. By the laws of most of the States where fish-ways are needed, it devolves upon the owner o the dam to build and maintain a fish-way. The question of material and

* See illustration.

mode of construction (providing the requisite form be secured) may, in general, be with safety left to him, who may be supposed to best consult his own interests in those matters. It may, however, be remarked that, except in a few instances, wood is the most economical material, and, where facilities exist for wetting the structure occasionally, perhaps every day or two during the drought, it will not decay for a great many years. In the construction of spirals, wood is the only material that can now be economically used; and that form offers peculiar facilities for preservation from rot by water-soaking.

The cost of a fish-way depends so largely on the site and on the cost of material and labor in the vicinity that no general estimate can be made. The cost of extended and reversed fish-ways varies more than that of the spirals, on account of the great variation in the amount of work required in the foundation. A few instances may be mentioned.

The fish-way at Union Mills, on the Saint Croix, (Plate XXIV, figs. 1, 2, 3, and 4,) being about 70 feet long, 8 feet wide inside, of the Foster pattern, built of solid timber, with walls about one foot thick, with an extensive foundation of crib-work, in deep water, and the whole strong enough to resist the heaviest freshets with logs and ice, cost $600.

A fish-way at Pembroke, on the Penmaquan River, about the same length, 70 feet, 8 feet wide, of lighter material, being not exposed to great floods, was built for less than $100.

The estimates of experts on the cost of the execution of several plans at Augusta on the Kennebec have ranged from $1,500 to $3,000. The dam is about 18 feet high, and the river is subject to great floods.

A stone fish-way has been built at Brunswick on the Androscoggin for $1,100. It is 180 feet long, and 10 feet wide inside, to pass over a dam 18 feet high. To secure its inclined floor, a considerable amount of excavation of rock was required. The walls are about two feet thick and the partitions about one foot, both laid in cement.

A spiral fish-way has been devised for the dam at Cumberland Mills on the Presumpscot, over a dam about 10 feet high. The ground-plan inside the walls is 24½ feet long and 15 feet wide. It is to be built of pine timber and plank, worth $20 per thousand feet; and the engineer of the mills, Mr. John Warren, estimates its cost at $365.

The fish-ways at Lowell and Lawrence, on the Merrimack, cost about $3,000 and $9,000, respectively; and that at Holyoke, on the Connecticut, a still larger sum.

The fish-way of 1873, at Columbia, on the Susquehanna, being a simple inclined plane, 120 feet long and 60 feet wide, with a heavy guard-crib on either side, cost $11,053.

The general introduction of the spiral form will greatly reduce the cost of constructing fish-ways over such high dams as those at Lawrence and Holyoke, where a large part of the expense is incurred in the foundation.

XXIV.—OBSTRUCTIONS TO THE ASCENT OF FISH IN CERTAIN RIVERS.

For the purpose of more accurate information as to the accessibility of certain interior waters to salmon, shad, and other anadromous fishes, passing upward from the portion of the ocean or of the great lakes to which the former are tributary, I secured the valuable co-operation of certain gentlemen, whose reports are herewith communicated. With that of Mr. E. M. Stilwell, fish-commissioner of Maine, has been incorporated a similar communication from Mr. Charles G. Atkins. Dr. M. C. Edmunds has furnished a report on the streams connected with Lake Champlain and the Saint Lawrence River. Both these articles are accompanied by maps. Other articles of less magnitude, but of much interest, have been supplied of some rivers in Virginia, by Mr. McKennie, through Thaddeus Norris, and of tributaries of Lake Michigan, by Mr. J. F. Ingalls and by Mr. Milner.

A—OBSTRUCTIONS IN THE RIVERS OF MAINE.

By E. M. Stilwell.

SAINT CROIX RIVER.

1. Calais, fifteen miles*; Union Mills dam, according to tide, 10 feet.
2. Barring, nineteen miles; dam, 7 feet.
3. West Branch, forty miles; Princeton dam, 8 feet.
4. Vanceborough, E. B., fifty-seven miles; dam and fish-way.
5. Forest City, eighty-two miles; dam, 10 feet.

PENMAQUAN RIVER.

1. One and a half miles from mouth; grist-mill dam, 7 feet; saw-mill dam, 9½ feet.
2. Iron Forks, one mile; dam, 25 feet.
3. Little Falls, four miles; dam, 20 feet.

DENNYS RIVER.†

1. Dennysville dam, 10 feet; Dennysville dam, 1½ miles; 12 feet; fish-way.
2. Millwaukie, 4 miles; dam, 14 feet; fish-way.
3. Meddybemps, 20 miles; dam, 10 feet.

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* Distance from mouth of river.

† See map for dams on tributary.

ORANGE RIVER.

Three dams near mouth, all with fish-ways.

EAST MACHIAS RIVER.

Main river, East Machias, 1 dam 8 feet high; 1 dam 14 feet high; 1 dam just above, 10 feet high.

Tributary, 1 dam.

MACHIAS RIVER.

1. Lower Falls, 3 miles; dam, 14 feet.
2. Upper Falls, dam, 14 feet.
3. Whitneysville, 8 miles; dam, 15 feet.

WESCONGUS, OR PLEASANT RIVER.

Main river, 1 dam at Columbia, 6 feet; 1 dam at Columbia, 7 feet 1 dam above, 5 feet; 1 dam above, 7 feet; 1 dam above, 7 feet; 1 dam above, 5½ feet.

NARRAGUAGUS RIVER.

Main river, 1 dam at Cherryfield, 9 feet; 1 dam at Cherryfield, 12 feet; 1 dam at Cherryfield, 9 feet; 1 dam at Cherryfield, 10 feet; 1 dam at Cherryfield, 10 fect; 1 dam at Deblois, 6 feet.

UNION RIVER.

Main river and tributaries, 8 dams, as per plan.

(See Atkins's Report, p. 300.)

PENOBSCOT RIVER AND TRIBUTARIES.

1. Veazie dam, 10 feet high, with fish-way.
2. Basin Mills, 4 miles above; fish-way, dam, 8 feet.
3. Orono dam, 8 feet high, with fish-way.
4. Great Works dam, 6 feet high, with sluice, passable for salmon.
5. Foot of North Twin Lake, West-Branch dam, 16 feet high; open from 25th day of June.
6. East Branch of Penobscot, dam at foot of Grand Lake, 30 miles from the forks of the river, 20 feet high; open from about 25th June to 1st July, to the end of the year.

Passadumkeag branch of Penobscot River.

7. Lowell, 12 miles; dam, 12 feet high.
8. Nickatons Lake, dam, 12 feet high; open 1st June.

Piscataquis branch of Penobscot and tributaries.

9. Milo, on Sebec River, dam, 10 feet high.
10. Brownsville, on Pleasant River, dam, 10 feet high.
11. Katahdin Iron-Works, on Pleasant River, dam, 10 feet high.
12. Sebec Village, at foot of Sebec Lake, dam, 12 feet high.

13. Head of Sebec Lake, at mouth of Ship-Pond Stream, dam, 12 feet high.
14. At foot of Ship-Pond, dam, 8 feet.
15. On Ship-Pond Stream and foot of Long Pond, dam, 8 feet high.
16. East Dover, dam, 18 feet high.
17. Dover and Foxcroft, dam, 18 feet high.
18. Guilford, dam, 10 feet high.
19. Abbot, dam, 16 feet high.

Mattawamkeag branch of Penobscot River.

20. Gordon Falls, 4 miles; dam, 14 feet high.
21. Slurgundy, 2½ miles above; dam, 15 feet.
22. Kingman tannery, dam, 18 feet.
23. West Branch Lake, 30 miles; dam, 8 feet.
24. Rockybeme Lake, 23 miles from Island Fall, dam, 10 feet.
25. East Branch, Mattawamkeag, 16 miles from Haynesville, dam, 12 feet.
26. Smyrna, dam, 6 feet.

SAINT GEORGE RIVER.

1. Warren Low Falls, 6 miles; dam, 9 feet.
2. Upper Falls, 6½ miles; dam, 10 feet.
3. Union dam, 33 miles; 10 feet.
4. Hill's dam, 34 miles; 12 feet.

MEDOMAC RIVER.

Main river, 1 dam at Waldoborough, 10 feet; 1 dam at Waldoborough, 8 feet; 1 dam at Waldoborough; 1 dam at Waldoborough, 10 feet; 1 dam above; 1 dam at North Waldoborough, 6 feet; 1 dam at North Waldoborough, 6 feet.

DAMARISCOTTA RIVER.

Natural fall, 50 feet; not a salmon-river.

SHEEPSCOT RIVER.

1. Upper dam, 31 miles; dam, 14 feet.
2. Cooper's Mills, 31 miles; dam, 14 feet.
3. Whitefield, 27 miles; dam, 12 feet.
4. King's Mills, 22 miles; dam, 15 feet.
5. Alna, dam, 10 feet.

KENNEBEC AND TRIBUTARIES.

1. Augusta, dam, 26 feet high.
2. Waterville, 18 miles above Augusta, falls, 18 feet in 50 rods; dam, at head of falls, 18 feet high.

3. Fairfield, or Kendall's Mills, 3 miles above Waterville, dam, 8 feet.

4. Somerset Mills, 3 miles above Kendall's Mills, dam, 8 feet.

5. Skowhegan, dam, 14 miles above Kendall's Mills, 12 feet.

6. Anson.

7. Moosehead Lake, dam at outlet, 8 feet.

1. *Sebastacook branch of Kennebec:* 18 miles above Augusta, dam, 7 feet; and one mile above, another dam, 8 feet.

2. Clinton, 11 miles above, dam, 8 feet; Burnham, dam, 12 feet; Unity, dam.

3. Pittsfield, 10 miles above, dam, 8 feet; Detroit, dam, 7 feet; Hartland, dam, 7 feet.

4. Newport, 8 miles above Pittsfield, dam, 8 feet.

1. *Carrabasset branch of Kennebec:* 1 dam at East New Portland; 1 dam at Kingsfield.

Sandy River and branches, tributary to Kennebec.

1. Starks, 2 dams.
2. New Sharon, dam, 8 feet.
3. Farmington Falls, dam, 8 feet.
4. North Chesterville, 1 dam, 12 feet.
5. East Wilton, 1 dam, 10 feet.
6. East Wilton, 1 dam, 13 feet.
7. East Wilton, 1 dam.
8. East Wilton, 1 dam.
9. East Wilton, 1 dam, 5 feet.
10. Wilton, 1 dam, 7 feet.
11. Wilton, 1 dam, 9 feet.
12. Wilton, 1 dam, 6 feet.
13. Wilton, 1 dam.
14. Wilton, 1 dam, 15 feet.
15. Phillips, 1 dam, 20 feet.

1. *Cobbosseecontee stream:* Gardiner, 8 dams.

Androscoggin branch of the Kennebec.

1. Brunswick, dam, 14 feet.
2. One-fourth mile above, dam and fish-way, 14 feet.
3. Lisbon Falls, 8 miles; dam, 10 feet.
4. Lewiston Falls, dam, 18 feet; falls, 35 feet in 50 rods.
5. Livermore Falls, 20 miles; dam, 7 feet.
6. Jay, 8 miles; dam, 8 feet.
7. East Rumford, Rumford Falls, 25 miles, 70 feet vertical pitch, natural falls.

Little Androscoggin: Auburn, 2 dams; 1 dam at Minot, 11½ feet; 1 dam above, 13 feet; 1 dam at Mechanic Falls; 1 dam at Mechanic Falls, 14 feet; 1 dam at Mechanic Falls, 14 feet; 1 dam at Welchville, 10 feet; 2 dams near Paris; 1 dam at Oxford, 10 feet; 1 dam at Oxford, 13 feet.

Nerinscot: 1 dam near mouth, 11 feet; 1 dam above, 12 feet; 1 dam, Turner, 12 feet; 3 dams at Buckfield; 2 dams at North Buckfield.

Webb's River: 1 dam at Dixfield; 1 dam at Berry's Mills.

PRESUMPSCOT RIVER.

1. Presumpscot Falls, 1 mile from mouth, accessible to salmon, shad, and alewives.
2. Cumberland Mills, nine miles; dam, 9 feet.
3. Saccarappa, ten miles; 2 dams, 10 and 14 feet.
4. Mallison Falls, sixteen miles; dam, 12 feet.
5. Gombo Falls, eighteen miles; dam, 8 feet.
6. Great Falls, twenty-three miles; dam, 20 feet.
7. Steep Falls, twenty-four miles; dam, 11½ feet.
8. Lindsey's Falls, twenty-five miles; dam, 14½ feet.
9. Sebago Lake, twenty-seven miles.

Songo River: Harrison, 3 dams; South Waterford, 2 dams.

Crooked River: Ede's Falls, 1 dam, 8 feet; 1 dam, 7 feet; Bolster's, 1 dam, 9 feet; 1 dam, 11 feet; 1 dam, 11 feet; North Waterford, 1 dam, 8 feet.

SACO RIVER AND TRIBUTARIES.

1. Biddeford and Saco, 2 dams, 26 and 6 feet.
2. Union Mills, 15 miles; dam, 14 feet.
3. Salmon Falls, 16½ miles; dam, 10 feet.
4. Box Mills, dam, 11 feet.
5. Moderation, dam, 12 feet.
6. Bonny Eagle, dam, 10 feet.
7. Steep Falls, dam, 12 feet.
8. Hison Falls, natural fall of 80 feet.

Little Ossipee: 2 dams near mouth; Ossipee Falls, 1 dam, 7 feet; Newfield, 1 dam, 9 feet; Newfield, 1 dam, 10 feet; North Shapleigh, 1 dam, 12 feet; North Shapleigh, 1 dam, 11 feet; North Acton, 1 dam.

Great Ossipee: Kezar Falls, 1 dam.

MOUSAM RIVER.

18 dams, as per plan.

SALMON FALLS RIVER.

Main River: 1 dam, 19 feet; 1 dam, 22 feet; 1 dam, 19 feet; 1 dam, 33 feet; 1 dam, 33 feet; 1 dam, 33 feet; 1 dam, 8 feet.

Tributary: 1 dam, 17 feet; 1 dam, 20 feet; 1 dam, 20 feet; 1 dam, 20 feet.

B—OBSTRUCTIONS IN THE TRIBUTARIES OF LAKE CHAMPLAIN.

BY M. C. EDMUNDS.

WESTON, VT., *November* 22, 1872.

DEAR SIR: In accordance with instructions from you under date of July 26, 1872, I proceeded to make examinations of the rivers in Lake Champlain Valley and the south shore of Lake Ontario. In proceeding to the work, I took up first in order Lake George. This lake is situated to the west of Lake Champlain, and in an obtuse angle to its flow northward. It is thirty-six miles long, and from one to three miles wide. It is principally made up of large springs at the bottom of the lake; some of the springs are very large, covering an area of one-half acre or more. High mountain-ranges extend on either side, from which issue small brooks and rivulets from three to five miles long, only one of which is sufficiently large for manufacturing-purposes. The water-shed of this lake is quite limited in extent, as the mountains shut in close upon the water's edge, and the streams are consequently rapid and precipitous. The lake debouches into Lake Champlain at a point near the village of Ticonderoga,* N. Y., and descends over high, perpendicular falls and roaring cataracts, 250 feet, in a distance less than two miles. No salmon or migratory fish was ever known to be in this lake, and the reasons are quite obvious, in the presence of the falls mentioned above.

I gave but little notice to the streams emptying into this lake in view of the foregoing facts, and can say only this in conclusion, that there would be little feasibility in introducing the migratory fishes. The probabilities are that it never could be stocked with these fishes without an enormous outlay for fish-ways. It is, however, one of the finest inland waters of America for the breeding of fish, because of the purity of its water. For all of the fresh-water *Salmonidæ* it is *especially* adapted, and is now, as formerly, largely inhabited by them.

I took up next in order the inspection of Lake Champlain and its tributaries, not visiting, however, any localities south of the junction of Lake George with this lake, owing to my previous knowledge of the marshy condition of the country surrounding the immediate portion of that part of the lake.

No rivers of any importance debouch into this lake between Ticonderoga and the mouth of Otter Creek in Vermont. The latter river is the longest in Vermont, and rises in the southwestern portion of the State, flowing northwesterly, and empties into the lake at about 44° 20′ north latitude. Eight miles from its mouth, at or near the city of Vergennes, is situated a natural fall 35 feet in height, over which no salmon was ever known to pass. I found that salmon frequented the river at

* See map.

an early day as far as the falls at Vergennes, although not in such abundance as in the rivers farther north, this being the most southerly river, formerly inhabited by the salmon, on the lake.

The knowledge of their once having been in the river is traditional, as I know of no writers in later or earlier times who have made a record of the fact. What information I obtained with regard to this river was from persons who had heard their grandfathers' stories about catching salmon in the Otter Creek below its falls. The present condition of the river offers no very promising inducements for beginning the experiment of restocking the same with salmon; yet, with a suitable fish-way over the falls, favorable results might follow the experiment, as the character of the water is such as to warrant a belief that much might be accomplished in this direction. From this point of observation, I journeyed northward to the Boquet River, which empties into the lake nearly opposite the city of Burlington, Vt. This river rises in the Adirondack Mountains of New York, in the famous John Brown tract. It flows northeasterly, through a mountainous region, until it reaches Willsborough, where is situated a high natural fall. From this point three miles from the lake, the river is navigable for the largest vessels, and it is said that in former times it was largely inhabited by the salmon.*

There is a small stream emptying into the river at Willsborough, called Willsborough Brook, rising in the north part of the township, in Rattlesnake Pond, which would doubtless be a good stream for the introduction of salmon.

It is doubtful whether the salmon, in an early day, ever got up the main river beyond the falls at Willsborough; but, that they found their spawning-beds and special haunts below the falls in small brooks, coves, and inlets, which are very numerous, we have sufficient evidence to believe. It is told, however, that salmon formerly ascended the falls, and got a long distance up the river into the interior. If it were not for the dams and falls, which are quite numerous, the river might be restocked with the salmon. This difficulty could be easily overcome in the erection of suitable fish-ways.

The next place visited was the Winooski River in Vermont, which empties into the lake at about 44° 30′ north latitude. The Winooski (formerly Onion River) was once a fine salmon-stream, and has its source far back in the mountains of the State. About five miles from its mouth is situated a natural fall, over which the salmon formerly passed, and took a long journey into the interior. It is said that in an early day salmon were caught in large quantities at the foot of these falls; and that for days and weeks together they would be found in great abundance at this point, and at night scale the heights.

The Winooski is fed by numerous small brooks and rivulets, which afford nice fields for the growth of this delicious fish. But for this natural fall, which is now surmounted by a high dam, the stream might

* See Watson's History of Essex County, New York. Albany, 1869. pp. 351, 352.

again be successfully restocked. With the introduction of fish-ways, this difficulty could, of course, be overcome.

You are next introduced to the Lamoille River, which I regard as the most favored region in Vermont in which to begin the experiment of restocking with salmon. It is a more rapid stream than the Winooski; has more dams situated on it, yet no high perpendicular fall. Although it has many cataracts and cascades, yet not being abrupt, and the dams and falls being low, they could be easily surmounted by the salmon without the aid of fish-ways. The bed of the river being gravelly and the water clear and cold, I think it affords unsurpassed advantage for the introduction of salmon. It will doubtless be the stream upon which operations will first be commenced.

The Missisquoi River, the last of the large rivers on the east side of the lake, empties itself into Missisquoi Bay at Swanton, Vt. This river is partly a Canadian river, taking its rise in the southeastern townships of the Lower Canadas, and flows southerly into the State of Vermont, and then in a westerly direction to the lake. This stream was once a great salmon-stream, like the others mentioned; and in an early day the salmon ascended the river nearly fifteen miles, to what is now called Highgate Falls. Over these falls no accounts are had of salmon passing, and I question very much their ability to do so, as the fall of water is somewhat perpendicular, and from 18 to 20 feet in height. There is only one dam between the mouth of the river and Highgate Falls, over which an easy fish-way might be constructed.

From the mouth of the river to Highgate Falls, several small streams debouch into the river, wherein the salmon would find suitable spawning-ground. This river is only second in importance to the Lamoille as a salmon-stream.

The next streams visited were the Saranac and Salmon Rivers, on the west side of the lake, in the State of New York. The Saranac River, which empties itself into the lake at Plattsburgh, is one of the finest rivers, comparatively speaking, in the whole Lake Champlain Valley for salmon, but, unfortunately, full of high impassable dams,* which, in connection with the shallowness of the water below them, render fish-ways in a measure impracticable. Twenty miles up this river, at Russia, are situated the Great Falls of the Saranac. These are a succession of falls, some of which have a perpendicular height of 35 feet. Large stories are told of the abundance of salmon inhabiting this stream at an early day, and I have no doubt that they were all true from what I saw of it. Mr. Fouquet, the proprietor of the Fouquet Hotel at Plattsburgh, informed me that his grandfather related the fact that he had seen immense schools of salmon making into the mouth of this river in his day, in such abundance as to completely fill the river, rendering their capture by the *cart-load* an easy matter. The last salmon known to have been caught upon this stream was in the spring of 1824.

* See Saranac River Fisheries—People *vs.* Platt, 17th New York Law Reports. Johnson, 1819.

Four miles south of Plattsburgh, a small stream, twenty to thirty miles long, called Salmon River, debouches into the lake, deriving its name from the abundance of salmon formerly caught there. This river has upon it a series of dams, almost innumerable. These are so high and in such close proximity to each other that there is no practicability in introducing salmon or any other of the migratory fishes. From an early day to within a few years, it has been largely used as a manufacturing stream, but an apparent decrease in the quantity of water indicates that it will not continue to afford the manufacturing facilities heretofore enjoyed.

I noticed several high dams that were going to decay, and which I am told will never be rebuilt. Should the time arrive when the stream will be free from these dams, or to such a degree that fish-ways would be practicable, I know no reason why the stream may not again be stocked with the valuable fish from which it derives its name. A Mr. Jones, living upon the bank of the river four miles from its mouth, informed me that so plenty were the salmon in an early day that a twenty-pounder could be bought for a "plug of tobacco;" that when a boy he saw his father take a one-horse load of salmon from the stream in the morning before breakfast, with no other implement than a common "pitchfork."

The next rivers in order of inspection were the Little and Big Chazy, the former of which I did not examine very closely, as it was never much of a salmon river, and is now obstructed with high, impassable dams. Of the Big Chazy, emptying into the lake two miles south of Rouse's Point, I made a thorough inspection, and think it the best river on the west side of the lake in which to begin experiments.

This river was the only one marked by Champlain on his discovery of the lake as in any way noted for its salmon-fishery. At or near where is now located the village of Champlain, he noted on his chart of the lake, "Salmon-Fisheries," it being doubtless the place where their greatest numbers were found. This river is navigable five miles from its mouth; and, although there are a great number of dams above this point, they are so low that they could be easily overcome by the salmon in their ascent of the river.

It is within the recollection of some of the older inhabitants on this river when the salmon ceased their annual visits to the Chazy; and it is their opinion that it was neither dams, sawdust, or other obstructions in the river that caused them to forsake it, but that the *last fish* coming into the river was caught.

From the Chazy I proceeded to St. John's, Province of Quebec, for the inspection of the Richelieu.

The Richelieu River proper begins here, although many ascribe its source at or near a point between the United States and Canada, by reason of the lake contracting itself into a channel not much wider than a large river; yet I think it must be conceded that the river commences at St. John's, twenty-three miles farther north of the line between the two countries. My reasons for this opinion are that at St. John's the

river contracts itself into quite a narrow channel, flowing over a gentle inclination, sufficient to cause a slight ripple in the water, and thus leaves no doubt of its river character.

St. John's is the head of navigation on Lake Champlain, and it is at this point where a ship-canal begins and from here extends twelve miles northerly to Chambly, where it terminates in the river again.

The Richelieu from St. John's to Chambly is quite a rapid stream, running at an average rate of speed of four miles per hour.

At Chambly, the river widens into a large basin or small lake, and from this point to the Saint Lawrence it is navigable for the largest class of vessels.

The character of the river between St. John's and Chambly is such as to admit of the passage of all the migratory fishes coming from the sea, and they will find an easy ascent into the lake. There are just below St. John's three eel-weirs, the first being of stone and the second and third of wood.

I am told it is quite a successful weir or trap for catching eels, as also for occasionally impounding fish. This whole structure, however, is measurably destroyed every spring by the ice in the river, and has to be rebuilt every season. I was assured by the Canadian government that these obstructions should be removed if they offered any hinderance to the free passage of the migratory fishes. They would doubtless afford no serious objection to the early run of salmon; but for the late run of shad or salmon, they would prove a great barrier.

I am of the opinion that an order should issue from the Government at Washington asking that these obstructions be removed, or that they should not be rebuilt after the summer of 1874 or of 1875, so that the shad and salmon placed in Lake Champlain in the years 1872 and 1873 may find an easy and safe descent to the Saint Lawrence.

The authorities at Ottawa gave me the most positive assurance that nothing should be wanting on their part to insure success to the project which our Government has in hand of restoring to Lake Champlain and its tributaries the migratory fishes. It is the opinion of some, however, that these weirs offer no serious objection to the ascent and descent of fish, as the smelt surmount them every year on their return to the lake. And if smelt can successfully pass them, why not the shad and salmon? Perhaps this may all be true, yet I should regard them as dangerous traps to the descending fish.

Farther down the river, there exists an occasional dam extending into the river about midway, but which offers no obstruction to the free passage of fish.

At Chambly, just before the river debouches into the basin before mentioned, there exists what are called the Chambly Rapids; these rapids extend up the river a distance of from one to two hundred rods, the river being quite wide and shallow at this point. They are never known to freeze over during winter, and it is here that the smelt may

be seen in great abundance in their midwinter journey to the lake. In view of the foregoing facts, it is readily seen that no serious impediments exist to the ultimate success of restocking Lake Champlain and its tributaries with the salmon.

I think the lake is well adapted to the introduction of these fishes, with its numerous rivers and brooks, coves and inlets, wherein these fish would find nice spawning-ground, or where they might be easily caught and artificially propagated to an extent that would make them as plenty in the future as in the past.

I am of the opinion that in former years the salmon never got up the large rivers into the interior of the country to any great extent, but that they found their fields for propagation around the mouths of the large rivers and in the coves and inlets of the lake. I reason thus from the fact that nearly or quite all of the large rivers have high natural falls upon them from five to fifteen miles inland, over which it would be impossible for salmon to ascend; and that their abundant increase in the lake was solely due to the nice gravelly coves and inlets so abundant along the shore of the lake and up the mouths of the large rivers. Many of the large rivers formerly noted for salmon have these coves to a great extent, while others have nice gravelly bottoms in their main channel near their mouths, that afforded a nice place for the salmon to deposit and protect their spawn through the incubation and hatching period.

Some of the bottoms of the rivers appear to have a peculiar slaty appearance, and the rivers are remarkable for their freedom from any sediment which might impair their facilities for salmon-breeding. The Saranac, Chazy, and Missisquoi Rivers are especially noted for this appearance.

The west shore of the lake north of Bulwagga Bay to the mouth of the Big Chazy is alternately rocky and gravelly, and the same is also true of the shore north of Shelburne Bay on the east side, while south of these points the shores are clayey, and the salmon formerly were never found. History does not record the fact that they ever existed in the lake south of 44° 20′ north latitude.

SAINT LAWRENCE RIVER AND LAKE ONTARIO.

The salmon formerly were very plenty along the southeast shore of the Saint Lawrence, inhabiting the lower reaches of the Chateaugay, St. Regis, Racquet, and Grass Rivers emptying into the Saint Lawrence within the Canadian Dominion, as also the Oswegatchie in the State of New York. Of these streams I took but little notice, but passed on to the inspection of the rivers immediately debouching into Lake Ontario proper.

Of these, first in order I inspected the Black River and Chaumont, both of which I found to have been formerly inhabited by the salmon. Neither of these rivers at the present offers any inducements for the introduction of the salmon, by reason of high and impassable dams.

Both of these streams at their outlets into the lake are susceptible of being made quite profitable fields for salmon-breeding could the trap-weirs and pound-nets be permanently excluded; but these are so plenty, and the fishermen so lawless, that it would be useless to begin any experiments here.

My attention was next directed to the Big Sandy Creek and Salmon River in Oswego County. The former of these ceased long ago to be a salmon stream, and received but slight notice at my hands, while the latter claimed my *special* attention, being the first river which I have yet found in all my travels in which the salmon are now found. I inspected the river several miles from its mouth upward, and found it all the way admirably adapted to the growth of salmon. There are several dams situated on the river, but so low and in such favorable localities as to give easy passage to the salmon. I found, on inquiry, the fact that several salmon were caught below and above the dams last fall, and that several were caught below the dams early the past summer. I think this, above all streams heretofore seen, to be the best calculated to commence the breeding of salmon artificially. It is quite evident that they ascend the river above the dams, and when above have a wide range and are free from the attacks of all predatory fish. An establishment might be built upon some favored locality above the dams where the process of artificial propagation could be begun and successfully prosecuted. I noticed several streams where such an institution might be begun, and where as favorable results could be effected as those attending the experiments of Wilmot at Newcastle, Ontario. There are no trap-weirs or pound-nets, as I am informed, in the mouth of the river to prevent the salmon from entering the same with safety. The people in this locality are all kindly disposed to aid and assist this project, and are qu'te anxious that experiments should be commenced here.

After leaving this river, I took up next in order of inspection the Oswego. This river has its source in the interior lakes of Central New York. It was also once a very noted salmon stream, and salmon ascended into the Cayuga and Seneca Lakes; but the canal, which extends from Oswego to Syracuse, follows nearly the whole course of this river, debouching into it, thus making it unfit for a salmon stream.

I visited several other small streams between this point and the Genesee, at Rochester, and found them equally well-noted salmon streams, as also the Genesee, as far as the falls, together with all streams between that point and the Niagara.

None of these streams visited are now inhabited by the salmon, but the testimony of all with whom I had any conversation on the subject confirmed the fact that they once had been salmon streams of greater or less celebrity. Their testimony all went to show that the last salmon that had ever inhabited these streams had been caught, and that neither sawdust nor other foreign matter had aught to do in their extermination.

It is a fact too apparent to need further confirmation that the trap and pound-nets have entirely exterminated this fish from the south shore of Lake Ontario. They have been set in the mouths of nearly all the rivers emptying into the lake, and consequently the fish have become an easy prey to the fisherman.

In conclusion, I would say that I found the Saint Lawrence to have once been inhabited very largely by the salmon, and it is the opinion of the inhabitants living along its banks that it might again be stocked.

Respectfully submitted.

M. C. EDMUNDS.

Prof. SPENCER F. BAIRD,
Smithsonian Institution, Washington, D. C.

C—OBSTRUCTIONS IN SOME OF THE RIVERS IN VIRGINIA.

BY M. MCKENNIE.

UNIVERSITY OF VIRGINIA, *October* 2, 1872.

MY DEAR SIR: Your esteemed favor of 30th ultimo came duly to hand on yesterday. As you are aware, I have been much interested in this question for several years, but I fear that little can be done until some cunning leech is able to apply some plaster to our people which shall arouse them to a sense of their duty to themselves and their children. The project started in a small way by the legislature of 1870–'71 was dropped by that of 1871–'72.

In reply to your inquiry, I beg to state that, on James River, the first dam above Richmond* is 9 miles above that city.

The Appomattox is closed by a dam one mile above Petersburgh.

The Rappahannock is closed by a dam one mile above Fredericksburgh. The Rapidan is a tributary of Rappahannock.

The Pamunkey and Mattapony unite to form the York, and not far above their junction these streams are closed.

The Potomac is free pretty high up. Black bass have been caught in the Shenandoah at Port Republic, which place they have reached by going over the low dams which exist below that point.

The Chowan is also closed a very short distance above its proper mouth at the head of tide-water. The Roanoke is closed at no great distance from Weldon.

By introducing the fish into New River, or the Greenbrier, near Ronceverte, on the Chesapeake and Ohio Railroad, the headwaters of the Ohio might be stocked, if the length of the Mississippi and Ohio do not prove an obstacle to the ascent of the fishes to their spawning-grounds.

I am, yours, truly,

M. MCKENNIE.

THADDEUS NORRIS, Esq.,
Philadelphia.

* Richmond is at the head of tide-water.

D—CHARACTER OF THE STREAMS ON THE NORTHERN SHORE OF LAKE MICHIGAN.

BY J. F. INGALLS.

WAUKEGAN, ILL., *August* 23, 1872.

DEAR SIR: I have gathered some information in regard to the rivers emptying into Green Bay, and also of some of those which empty into Little and Big Bays de Noquet and Lake Michigan. Some of them were visited by myself, and others by reliable parties, who gave me the information. I think the following report is essentially correct.

PENSAUKEE RIVER.

The length, following the course of the river, is seventy-five miles; it is rapid, clear, and comparatively cold, with sandy and gravelly bottom, and in some places rocky; the banks are high, except near the mouth where there are marshes; the depth, except near the mouth, is from two to three feet. There is one water-power mill about one mile from the mouth.

OCONTO RIVER.

This river has a length of about one hundred miles. There are marshy shores extending up the stream for about three miles from the mouth; it is comparatively dead water for about one mile from the mouth, which has a width of about 150 feet. Above the marshy region is a considerable stretch of the river, having an average depth of 6 feet; farther up are rapids and shoals, with gravelly bottoms, the water being clear and cold. There are seven steam-mills at the mouth; about twenty miles up the river is a mill-dam, which does not reach entirely across; and above this, there are a few driving-dams, which are open except in the spring.

PESHTIGO RIVER.

The length is about seventy-five miles; its shores are marshy at the mouth, where it has a width of about one hundred and fifty feet. Above the marsh are high wooded banks, and the river is clear and cool, with sandy and gravelly bottom and frequent rapids. There is one steam-mill at the mouth, and one water-mill with a dam eighteen miles above at Peshtigo Village.

MENOMONEE RIVER.

The length of this river, measuring either of its branches, is about one hundred and fifty miles. One and one-half miles from the mouth are rapids, and in the shoals are placed three log-dams, with open chutes at the sides for the passage of logs. Thirty miles up the river is Grand Rapids, with thirty feet fall in two miles. Fifty miles above these are the White Rapids; twelve miles above the latter are the Pemina Falls, with a nearly perpendicular descent of thirty feet. Twenty miles above these are the Sturgeon Falls, with a descent of forty

feet, in which are log-chutes, overcoming about six feet of the descent. Fifteen miles above these are the Lower Quinesec Falls, having a descent nearly perpendicular of sixty feet. A series of rapids extends above this for two miles to the Big Quinesec Falls, which have an almost vertical fall of eighty feet. For the next forty miles along the Brulé branch, the water is very rapid, and beyond this the surface is level.

The Michigaumee branch is very rapid, and heads in Lake Michigaumee. The Mequacumicum branch is also very rapid, and heads in small lakes. Below Quinesec are two large branches of rapid water on each side. The banks of the streams are generally high and rocky, and for a great part heavily timbered. The river at the mouth is about one-third of a mile wide; above the first falls, it is about one hundred and sixty yards wide. There are ten steam-mills at the mouth.

CEDAR RIVER.

The length of this river is one hundred miles. Its width at the mouth is about one hundred and fifty feet; two miles above the mouth, it has a depth of eight feet; above this, it is shoaler, with rapids; the first rapids have a descent of fifteen feet in one-half mile; above this are occasional rapids; then a slower current, with a sandy bottom; and again, rapids, with a rocky and gravelly bottom. The waters are clear and cold; the banks are high and heavily timbered. There is one steam-mill at the mouth, and three log-dams higher up the river.

BARQUE RIVER.

This stream is about fifty miles long; its width at the mouth about forty feet. There is scarcely any current for about one-fourth of a mile; above this, it is rapid, with a stony bottom for about one-fourth of a mile; then, for two miles, deep quiet water, about six or eight feet deep, with, in many places, marshy shores; above this, it is rapid, with high banks, and heavily timbered. The water is clear and cool. There are no mills on the river.

FORD RIVER.

This river has a length of about one hundred and twenty-five miles; its width at the mouth is one hundred and fifty feet; it has a depth for two or three miles of about three feet; above that, it is shallower, with occasional rapids. It has high banks heavily timbered. There is one steam-mill at the mouth, and no dams on the river.

ESCANABA RIVER.

The length of the river is about seventy miles; its width for fifteen miles above the mouth is about seventy-five feet; rapids and a mill-dam are found three miles above the mouth; above the dam the river runs over a flat ledge; it has high banks, and is heavily timbered.

WHITEFISH RIVER.

Its length is about seventy miles; its width fifteen miles from the mouth about seventy-five feet; it is rapid and runs over rocky bottom and sandy flats; there are no mills; the shores are covered with heavy timber.

STURGEON AND FISH DAM RIVERS.

These streams are very similar in character to the Whitefish River.

MONISTIQUE RIVER.

The length of this river is about seventy-five miles; it has sources in large lakes; its width at the mouth is about one hundred and fifty feet; forty rods from the mouth there are rapids and a mill-dam, and still higher up marshes and lakes.

SEUL CHOIX RIVER.

This is a small brook, six miles west of the point, twenty feet wide; it is rapid and about twelve inches deep; it heads in a lake one and one-fourth miles from Lake Michigan, and runs through dense swamps.

There is another small stream three miles north of Seul Choix Point; it is twenty-five feet wide at the mouth; there are six inches of water on the bar outside; it is shoal and rapid; on the upper portion, there is heavy timber; it heads in a lake four miles from the mouth.

One-half mile farther east is a small stream thirty feet wide at the mouth; it flows over flat limestone rock into Lake Michigan; it widens to about one hundred feet, and beyond this higher up it is shallow, rocky, and rapid; heavy timber covers the banks; it heads in a lake; it is deep enough at the mouth to float a small boat.

The more northerly streams I have mentioned are clear and cold. The fish inhabiting all of them are principally pike, dory, pickerel, perch, sturgeon, black-bass, catfish, and sunfish.

I cannot recommend the Pensaukee or Oconto for salmon. The Peshtigo is a good river if the dams can be overcome. I would judge all of the others to be favorable for the experiment.

J. F. INGALLS.

J. W. MILNER, Esq.

E—CHARACTER OF SOME OF THE NORTHERN TRIBUTARIES OF LAKE MICHIGAN.

By JAMES W. MILNER.

The streams here referred to tributary to Lake Michigan I have not explored, but have gained some knowledge of their character from inquiry.

The letter from Mr. J. F. Ingalls contains full information about the more nothern rivers. The rivers here referred to are not in his list.

The Pine River, emptying at Charlevoix, which I ascended fifteen miles,

heads in the Jordan River, which is a very cold, rapid stream, containing the *Thymallus tricolor*, of Cope. The mouth of the Pine is a sharp rapids.

Elk Rapids, though emptying a large quantity of water into Grand Traverse Bay, would probably not be favorable for salmon, as it heads in a series of large lakes.

The Carp River.

The Betsey River.

The Manistee is a large, long river, emptying through a lake and a bay. The headwaters are very cold, and contain the grayling. There are twenty-eight mills, all steam, built on the shore of the lake, and an immense number of logs are rafted down every year. I believe the sawdust at the mouth would not be as objectionable for salmon as for whitefish, as I suppose they frequent the milling-rivers in Maine and along the Canada shores.

The Muskegon is another large stream containing the grayling, which is, I suppose, an indication of its being clear and cold.

There are other streams farther south; but the northern streams are probably most favorable for salmon.

The Escanaba River should be considered very favorable.

The Monistique is a favorable river if the steam saw-mill is left out of consideration.

The Pine River is especially favorable; it has a very sharp rapid at its mouth. The Jordan, at the head of the south arm of Pine Lake, would be a most favorable spawning-ground, as no dams obstruct the passage of the fish to its headwaters.

The Manistee has, perhaps, too many mills, and has also a large expansion into a lake not more than two miles long. Its broad waters would, undoubtedly, be favorable spawning-ground.

APPENDIX F.

NATURAL HISTORY.

XXV.—THE CRUSTACEA OF THE FRESH WATERS OF THE UNITED STATES.

By Sidney I. Smith.

A—SYNOPSIS OF THE HIGHER FRESH-WATER CRUSTACEA OF THE NORTHERN UNITED STATES.

The following synopsis is intended to include all the species of decapod and tetradecapod *Crustacea* known to inhabit the fresh waters of the Northern United States east of the Mississippi River. It has been limited to this particular region, because there has been at hand no material of any importance from other parts of the country, and because very few species have been described from localities outside of the region included. I should, perhaps, except from this statement the numerous species of *Astacidæ*, but these have been so recently monographed by Professor Hagen that it seems needless to repeat an account of them here. The fresh-water *Crustacea* are of great economic importance as food for very many, if not all, our fresh-water food-fishes; and on this account, as well as for purely scientific reasons, I hope this imperfect synopsis will be of service to all those interested in the subject, and trust it will hasten the preparation of a more complete work, including all the species of the United States.

I am indebted to Mr. Oscar Harger for the descriptions of the species of *Asellus* and *Asellopsis*.

MACRURA.

Family Astacidæ.

The following list of the species of this family I have compiled largely from Dr. Hagen's most valuable work,* to which the reader is referred for the full account of the species. The crawfishes of all the eastern part of the United States belong to the genus *Cambarus*, but the species appear to be quite numerous, and are difficult to distinguish without careful study.

Cambarus acutus Girard.

Proceedings Academy Nat. Sci. Philadelphia, vol. vi, p. 91, 1853; Hagen, op. cit., p. 35, pl. 1, figs. 1–5; pl. 2, figs. 106–127; pl. 3, figs. 143, 144.

This species, one of the largest of our crawfishes, has an extensive

* Illustrated Catalogue Museum Comp. Zool., No. 3; Monograph of the North American Astacidæ, 1870.

range, being found from New York State south to Louisiana, and northwest to Indiana and Illinois.

According to Dr. Abbott,* this species frequents running streams which have masses of vegetation growing in them; the animal resting upon the plants, usually near the surface of the water.

CAMBARUS AFFINIS Erichson.

Astacus affinis Say, Journal Academy Nat. Sci. Philadelphia, vol. i, p. 168, 1817.
Cambarus affinis Erichson, Archiv für Naturgeschichte, xii, 1846, p. 96; Hagen, op. cit., p. 60, pl. 1, figs. 19-22, 84, 85; pl. 3, fig. 152; pl. 5.

Dr. Hagen knew this species only from the Middle States and Maryland. According to Dr. Abbott, in the paper previously referred to, this is *the* river-species in the vicinity of Philadelphia. He says, "We have been able to find it, as yet, only in the Delaware River, usually frequenting the rocky bed, but also in fewer numbers on the mud-bottomed portions of the river. They are usually found resting under flat stones, well out from the banks of the stream, where the water is of considerable depth. Wherever the vegetation is dense, we have failed to find them; nor have we seen anything to indicate that it is a burrowing species."

CAMBARUS VIRILIS Hagen.

Op. cit., p. 63, pl. 1, figs. 23–28; pl. 2, figs. 128–132; pl. 3, fig. 155; pl. 8.

Canada West; Lake Winnipeg; Saskatchewan and Red River of the North; Ohio; Illinois; Iowa; Lake Superior; Missouri; Texas.

CAMBARUS PLACIDUS Hagen.

Op. cit., p. 65, pl. 1, figs. 76–79; pl. 3, fig. 158.

Illinois; Tennessee; Texas.

CAMBARUS JUVENILIS Hagen.

Op. cit., p. 66, pl. 1, figs. 29–33; pl. 3, fig. 157.

Kentucky River; Osage River, Missouri.

CAMBARUS PROPINQUUS Girard.

Loc. cit., p. 88; Hagen, op. cit., p. 67, pl. 1, figs. 34–38; pl. 3, fig. 158.

I have examined specimens of this species from as far east as Montreal, and Dr. Hagen records it from Northern New York to Lake Superior. It dwells in Cayuga Lake, New York; and Professor Verrill has found it in a lake at Madison, Wis.

It was found in abundance in the stomach of *Menobranchus lateralis*, at Ecorse, Mich., by Mr. J. W. Milner.

A crawfish, found in the valley of the Saint John's and Aroostook Rivers in Maine and New Brunswick, is most likely this species; but I have never had specimens for examination.

*American Naturalist, vol. vii, p. 80, February, 1873.

CAMBARUS OBSCURUS Hagen.

Op. cit., p. 69, pl. 1, figs. 72–75; pl. 3, fig. 154.

Genesee River, New York.

CAMBARUS RUSTICUS Girard.

Loc. cit., p. 88; Hagen, op. cit., p. 71, pl. 1, figs. 80–83; pl. 3, fig. 161.

Ohio; Lake Superior.

CAMBARUS IMMUNIS Hagen.

Op. cit., p. 71, pl. 1, figs. 101, 102; pl. 3, fig. 160; pl. 8.

North Carolina; Alabama; Illinois.

CAMBARUS BARTONII Erichson.

Astacus Bartonii Fabricius, Supplementum Entomologiæ Systematicæ, p. 407, 1798; Say, loc. cit., p. 167.

Cambarus Bartonii Erichson, loc. cit., p. 97; Hagen, op. cit., p. 75, pl. 1, figs. 47–50; pl. 2, figs. 135–139; pl. 3, fig. 166.

Cambarus montanus, Diogenes, pusillus, and *longulus* (?) Girard, loc. cit., pp. 88, 90.

This seems to be the commonest species in the Northern States. It is found in Vermont and Massachusetts, in the tributaries of Lake Champlain and Hudson River, and extends west to Lake Superior and south to New Jersey, Maryland, and Kentucky.

Professor Verrill has collected it under stones in cold brooks in Northern New York, and in McKean County, Pennsylvania; but, according to Dr. Abbott, it is, in the vicinity of Trenton, N. J., a burrowing species. He says, "The burrows, so far as we have observed them, have all been in the banks of the smaller streams and meadow-ditches, (and occasionally a colony of burrows in the river-bank, where peculiarly favorable,) a little below the usual water-line." It occurs in Mammoth Cave with *C. pellucidus*.

CAMBARUS ROBUSTUS Girard.

Loc. cit., p. 90; Hagen, op. cit., p. 80, pl. 3, fig. 156.

Western New York.

CAMBARUS OBESUS Hagen.

Op. cit., p. 81, pl. 1, figs. 39–42; pl. 3, fig. 163; pl. 9.

Virginia; Illinois; Lake Michigan; Arkansas; New Orleans.

CAMBARUS PELLUCIDUS Erichson.

Astacus pellucidus Tellkampf, Müller's Archiv, 1844, p. 383, (*teste* authors.)

Cambarus pellucidus Erichson, loc. cit., p. 95; Hagen, op. cit., p. 55, pl. 1, figs. 68–71; pl. 3, fig, 148; pl. 6; Packard, American Naturalist, vol. v, p. 50, fig. 131, 1871; Hagen, American Naturalist, vol. vi, p. 494, 1872; Packard, Fifth Annual Report Peabody Academy of Science, Salem, p. 94, 1873.

Orconectes pellucidus and *inermis* Cope, American Naturalist, vol. vi, p. 419, fig. 116, 1872; Third and Fourth Annual Reports of the Geological Survey of Indiana, p. 173, 1872.

This is the blind species of Mammoth Cave, Kentucky, and Wyandotte Cave, Indiana. It is a fact worthy of notice that *C. Bartonii* occurs in Mammoth Cave with well-developed eyes.

Family PALÆMONIDÆ.

PALÆMON OHIONIS, *sp. nov.*

Carapax smooth, stout, and considerably swollen; the antennal and hepatic spines acute and of nearly equal size. Rostrum short, reaching scarcely to the tips of the antennal scales; its height in the middle about a third of the length, with a very high and arched lamellar crest above, not extending back of the middle of the carapax, and armed with ten to twelve slender teeth, of which the two or three posterior are back of the bases of the ocular peduncles, and more separated from each other than the anterior ones; inferior edge arcuate and armed with two or three teeth; the terminal third or fourth unarmed and directed slightly upward to the acute tip. Antennal scale about two-fifths as broad as long; the edges nearly parallel; the tip broad, subtruncate.

First pair of legs smooth and slender, the carpus, in large specimens, reaching beyond the tips of the antennal scales; merus and carpus subequal in length; hand very slender, about half as long as the carpus; fingers not quite half as long as the whole hand, cylindrical, armed with a few fascicles of setæ. Second pair of legs slender, either equal or somewhat unequal on the two sides; the ischium, merus, and carpus subequal in length; the carpus, in full-grown specimens, reaching much beyond the tips of the antennal scales, cylindrical, tapering proximally, and armed with scattering spinules, or short hairs; hand considerably longer than the carpus, slender; the basal portion of the propodus slightly swollen, nearly cylindrical, and armed with minute spinules; the fingers much shorter than the basal portion of the propodus, slender, not gaping, nearly straight, and armed with a few fascicles of short setiform hairs. Succeeding legs increasing slightly in length posteriorly; all of them with short, strongly-curved dactyli, and reaching slightly beyond the tips of the antennal scales.

Fourth and fifth segments of the abdomen produced at the posterior lateral angle, which is rounded in the fourth segment and acutely angular in the fifth. Sixth segment only a little longer than the fifth. Telson narrow, considerably shorter than the inner lamellæ of the appendages of the sixth segment, tapering regularly to the acutely triangular tip, which is armed each side with two slender spines and numerous long plumose setæ; the dorsal surface armed with two pairs of short spines.

Two specimens give the following measurements:

	Male.	Female.
	mm.	*mm.*
Length from tip of rostrum to extremity of telson	51.0	80.0
Length of carapax from orbit to middle of posterior margin	12.0	22.0
Breadth of carapax	7.8	14.0
Length of rostrum from its tip to base of ocular peduncles	8.2	13.5
Length of basal scale of antenna	8.4	32.0
Length of first pair of legs	16.0	8.3
Length of merus in first pair of legs	4.2	10.0

	mm.	mm.
Length of carpus in first pair of legs	4.5	4.7
Length of hand in first pair of legs	2.6	52.0-45.6
Length of second pair of legs	22.0	10.5- 9.6
Length of merus in second pair of legs	5.0	11.0- 9.8
Length of carpus in second pair of legs	4.2	16.4-13.6
Length of hand in second pair of legs	6.0	6.6- 6.1
Length of dactylus in second pair of legs	3.2	10.5- 9.6

The only specimens which I have seen were obtained by Prof. F. H. Bradley from the Ohio River at Cannelton, Ind., where he tells me it is taken for food.

PALÆMONETES EXILIPES Stimpson. (Plate I, fig. 1.)

Annals Lyceum Nat. Hist. New York, vol. x, p. 130, 1871.

Carapax smooth and the spines of the anterior border slender and acute. Rostrum nearly straight, scarcely reaching the tips of the antennal scales, and as long as the carapax from the bases of the ocular peduncles to the middle of the posterior margin; the dorsal crest slightly raised a little behind the bases of the ocular peduncles, and serrated with seven or eight equidistant, slender, and acute teeth, of which the second is directly above or slightly in front of the bases of the ocular peduncles; the tip unarmed, slender, and acute; the inferior edge armed with one or two teeth. Outer flagellum of the antennula much longer than the inner, and its secondary branch, which does not reach the middle of the flagellum, having only the terminal third free. Antennal scale broadest distally and evenly rounded at the tip.

First pair of legs slender, just reaching to the tips of the antennal scales; carpus a little longer than the merus, slightly thickened distally; hand nearly naked, scarcely thicker than the carpus and only half as long; fingers as long as the basal portion of the propodus. Second pair of legs slender; carpus nearly twice as long as the merus, slightly thickened distally; hand slightly thicker than the carpus, and nearly two-thirds as long; fingers slender, nearly naked, and a little shorter than the basal portion of the propodus; third, fourth, and fifth pairs of legs increasing successively in length, the fifth pair reaching to the tip of the rostrum.

Sixth segment of the abdomen slender, a little longer than the fourth and fifth together. Telson tapering regularly to the extremity, which is quite broad, but terminates in a slender and acute tip, each side of which there is a long and stout spine, and at each lateral angle a shorter one, while between the inner spines there are two long plumose setæ, arising from the under side and reaching beyond the tips of the long spines; each lateral margin armed with two short spines, one near the extremity, and another about three-fourths of the way from the base to the tip.

Two specimens, the first from Sandusky Bay, the second from Ecorse, Mich., give the following measurements:

	mm.	mm.
Length from tip of rostrum to tip of telson	30.0	32.0
Length of carapax from orbit to middle of posterior border	5.8	6.5

	mm.	*mm.*
Breadth of carapax	4.0	4.2
Length of rostrum from tip to base of ocular peduncle	5.8	6.4
Length of basal scale of antenna	5.4	5.6

I have seen only half a dozen specimens, which agree very closely with each other. All but one of them have seven teeth on the upper edge of the rostrum and two below, while this one has eight above and one below.

Collected by Mr. J. W. Milner at Ecorse, Mich., and in a grassy arm of Sandusky Bay, Lake Erie, known as the "Black Channel."

As Stimpson's specimens were from Somerville, S. C., and his description differed considerably from the Lake Erie specimens, I supposed, at the time the above description was written, that the northern specimens represented a distinct species. Since the manuscript was in the hands of the printer, however, I have received a large series of specimens collected by Dr. Edward Palmer in fresh-water streams in Florida, which evidently belong to Stimpson's species, and at the same time show that the Lake Erie specimens are undoubtedly of the same species. Most of the Florida specimens, like those from Lake Erie, differ from Stimpson's description in having the rostrum not longer than the antennal scales, but in a few of them it is very slightly longer, so that they agree well with the description.

Family PENÆIDÆ.

PENÆUS BRASILIENSIS Latreille.

Nouveau Dictionnaire d'Histoire Naturelle, vol. xxv, p. 154, (*teste* Edwards;) Edwards, Hist. Nat. des Crustacés, vol. ii, p. 414; Gibbes, On the Carcinological Collections of the United States, Proceedings American Association, 3d meeting, p. 170, 1850; Stimpson, Annals Lyceum Nat. Hist. New York, vol. x, p. 132, 1871; von Martens, Ueber Cubanische Crustaceen, Archiv für Naturgeschichte, 1872, vol. xxxviii, p. 140.

This is perhaps more properly a marine than a fresh-water species; but as it ascends fresh-water streams for long distances, it should be included in the present list. Dr. Stimpson says, "It was found in the Croton River at Sing Sing, N. Y., by Professor Baird, and by myself in a fresh-water creek near Somers' Point, N. J." It is common on the coast of the Southern States, and extends south to Brazil.

SCHIZOPODA.

Family MYSIDÆ.

MYSIS RELICTA Lovén. (Plate I, fig. 2.)

Om några i Vettern och Venern fauna Crustaceer, Öfversight af Vetenskaps Akademiens Förhandlingar, Stockholm, xviii, 1861, p. 285; Smith, American Journal of Science, 3d series, vol. ii, pp. 374, 452, 1871; and Preliminary Report on Dredging in Lake Superior, in Report of Secretary of War, vol. ii, Report of Chief of Engineers, p. 1022, 1871.

Mysis oculata, var. *relicta*, G. O. Sars, Histoire Naturelle des Crustacés d'Eau Douce de Norvège, 1e livraison, p. 14, plates 1–3, 1867.

Mysis diluvianus Stimpson, MSS.; Hoy, Transactions Wisconsin Academy, vol. i, p. 100, 1872, (no description.)

In this country, this species was first found in the stomachs of the white-fish. Subsequently, it was dredged in Lake Michigan by Drs. Hoy and Stimpson, in 40 to 50 fathoms, off Racine. In Lake Superior, I found it in a large number of the dredgings. It was brought up with sand and mud from 12 to 14 fathoms among the Slate Islands; from 4 to 6 fathoms in the cove at the eastern end of Saint Ignace; from 8 and 13 fathoms, with *Cladophora*, &c., on the south side of the same island; and in many of the hauls from 72 to 148 fathoms. Mr. Milner also dredged it, in 1872, in 60 fathoms, off Outer Island. It apparently furnishes a large part of the food of the white-fish in many parts of the lakes. Nine-tenths of the contents of the stomachs of white-fish taken at Outer Island were made up of *Mysis*.

I have carefully compared American with European specimens, and with the beautiful figures given by Dr. G. O. Sars, in his elaborate work on the Fresh-Water Crustacea of Norway, and am still unable to detect any characters by which to distinguish them. The form and ornamentation of the appendages seem to be exactly the same throughout, and the habits appear to be the same in the Scandinavian lakes and in Lake Superior. This species is also very closely allied to *Mysis oculata* Kroyer, a marine species found on the coasts of Labrador and Greenland. Lovén points out this close affinity, and regards it, together with the occurrence with it in the Scandinavian lakes of *Gammaracanthus loricatus* Bate, *Pontiporeia affinis* Lindström, and *Idotea entomon* Fabricius, all of which he regarded as specifically identical with previously-known marine forms, as evidence that the lakes where it is found were formerly filled with salt-water; that they had been cut off from the sea by the elevation of the Scandinavian peninsula; and that the differences between these species of the lakes and their allies of the neighboring ocean have been brought about by gradual changes in the habitats of the lake-species. Dr. Sars adopts Lovén's view as to the origin of these species in the Scandinavian lakes; regards the fresh-water *Mysis* as only a variety of the marine form; and considers, with good reason, the *Gammaracanthus* as a distinct variety of the marine species. He also points out the interesting fact that the slight differences (principally in the form of the telson) which distinguish the fresh-water from the marine form of the *Mysis* are exactly such as distinguish immature from adult individuals of the marine form, and are such differences as might have been brought about by a slight retardation of development, caused by the gradual change from a marine to a less congenial fresh-water habitat. Dr. Sars gives the Gulf of Bothnia as a habitat of the fresh-water variety, so that it is apparently not wholly confined to the fresh waters, but, like the *Pontoporeia affinis*, lives also in the somewhat brackish waters of the Baltic.

The occurrence, in Lake Michigan and Lake Superior, so far removed from the sea, of this *Mysis*, and other forms so nearly identical with marine species, is a fact of peculiar interest, which goes far toward

proving the marine origin of a part of the fauna of our great lakes. Dr. Stimpson,* in his first notice of his dredging in Lake Michigan, while regarding the *Mysis* as a new species, recognized its close affinity with "certain arctic forms," and supposes the same changes to have taken place in Lake Michigan as in the Scandinavian lakes. He says, "*Mysis* is a marine genus, many species of which occur in the colder parts of the North-Atlantic seas. One species, *M. relicta*, was found by Lovén in company with *Idothea entomon* and other marine *Crustacea* in the deep fresh-water lakes Wener and Wetter of Sweden, indicating that these basins were formerly filled with salt-water, and have been isolated from the sea by the elevatory movement of the Scandinavian peninsula, which is still going on. That the same thing has occurred in our own lakes is shown by the occurrence in their depths of the genus *Mysis*, notwithstanding the non-occurrence of marine shells in the Quaternary deposits on their shores. Kingston, on Lake Ontario, is, I believe, the highest point in the valley in which such shells have been found. Very probably, at the time when the sea had access to these basins, the communication was somewhat narrow and deep, and the influx of fresh water from the surrounding country was sufficient to occupy entirely the upper stratum, while the heavier sea-water remained at the bottom. After the basin had become separated from the ocean by the rise of the land, the bottom water must have become fresh by diffusion very slowly to allow of the gradual adaptation of the crustaceans to the change of element." In the entire absence of geological evidence of any oceanic connection with Lake Superior in recent geological times, the occurrence, in its otherwise strictly lacustrine fauna, of a very few forms of life showing close affinity with marine species, seems scarcely to warrant so positive an assumption of such a connection. At the time Lake Ontario was a part of the great Saint Lawrence Valley sea, there was, very likely, no insuperable barrier in the Niagara River to the upward migration of active swimming animals like *Mysis*, and some of the inhabitants of the upper lakes may have reached their present homes by this route, during the northward movement of the fauna, at the close of the Quaternary epoch. On the other hand, *Mysis relicta*, although originally derived from the strictly marine species *M. oculata*, may have existed long enough to have had the same history as some of the strictly fresh-water species, known to be common to Northern America and Northern Europe, since it has much the same geographical distribution. The investigation of the fauna of the lower lakes and Lake Champlain, and possibly of Lake Winnipeg, will throw much light upon these interesting questions, and it seems best to reserve any lengthy discussion of them until such investigations have been made.

Whether we should regard the fresh-water form of *Mysis* as a variety of *M. oculata* or as a distinct species, seems a matter of little import-

*On the Deep-Water Fauna of Lake Michigan, American Naturalist, vol. iv, p. 403, September, 1870.

ance, as long as we recognize the characters which distinguish them; but, as we know no truly intermediate forms, it is perhaps best for the present to regard it as a species.

In regard to the distribution and habits of this species in Europe, I translate the following remarks from Dr. Sars's great work. He says, "I have found it in Norway only in Lake Mjösen, the largest of our lakes. There, however, it is found in very great quantities, from shallow water (3 to 6 fathoms) to very great depths, (200 fathoms.) In Sweden, it seems to be much more widely diffused. Besides the two largest lakes of that country, Wener and Wetter, where it was first discovered, it has since been found in eight other Swedish lakes as well as in the Gulf of Bothnia. It has also recently been found by M. Malmgren in Lake Ladoga, the largest lake in Europe, as well as in many of the lakes of Finland. In habits, it seems to resemble the marine species. Like them, it generally lives collected together in great masses or in bands. It seems to prefer places where the bottom presents quite rapid inclinations; in such places, it is frequently found in great bands, swimming along the borders of these acclivities in the calm and elegant manner peculiar to the species of *Mysis*, making a digression only here and there to avoid some object which it fears. Its principal food seems to be composed of *Entomostraca*, with which these waters swarm. In the stomach of an individual, which I examined for the purpose, I discovered the remains of two or three species of *Cyclops*, a *Canthocamptus*, a *Bosmina*, a *Daphnia*, and a *Cypris*."

AMPHIPODA.

Family ORCHESTIDÆ.

HYALELLA, *gen. nov.*

First pair of maxillæ with rudimentary, very short, and uniarticulate palpi. Palpus of the maxillipeds composed of five segments; the terminal segment being slender and styliform, and the penultimate broad. Antennulæ, antennæ, and thoracic legs much as in *Hyale*. Telson short, stout, and entire.

This genus seems to be closely allied to *Hyale*, but differs from it and from the rest of the *Orchestidæ* in the palpus of maxillipeds, which has five instead of four segments, showing in this respect a remarkable approach toward the gammaroid group of *Amphipoda*. From *Hyale*, it differs also in the telson.

HYALELLA DENTATA, *sp. nov.* (Plate II, fig. 8, male, lateral view; fig. 9, female, lateral view; fig. 10, details.)

Body slightly compressed. First and second segments of the abdomen with the dorsal margin produced posteriorly into a well-marked spiniform tooth. Eyes nearly round, about equal in diameter to the thickness of the proximal segment of the peduncle of the antennula.

Peduncle of the antennula about as long as the head; the flagellum a little longer than the peduncle, and composed of seven to nine segments. Antennæ somewhat longer than the antennulæ; the two distal segments of the peduncle elongated and nearly equal; the flagellum usually but little longer than the flagellum of the antennula, and composed, usually, of eight to ten segments.

First pair of legs with the merus somewhat quadrate in outline; the ischium and carpus articulated on the two anterior margins, and reaching by, so as to touch each other; the postero-inferior angle being rounded and furnished with an area armed with numerous minute denticles, just below which there are a few slender setæ; the carpus much longer than broad, as long as the width of the first epimeron, somewhat triangular, and furnished with a line of setæ on each side near the distal extremity; the propodus slightly shorter than the carpus, a little less than half as broad as long; the lateral margins strongly curved, and armed with minute spinules; palmary margin transverse, nearly straight, and armed with a small tooth at the posterior angle; the dactylus very strongly curved, and its tip closing behind the posterior angle. Second pair of legs in the male greatly developed; the merus nearly quadrilateral, considerably longer than broad; the postero-inferior angle slightly rounded and armed somewhat as in the first pair; the carpus not longer than broad, with the posterior margin projecting into a process nearly as long as the merus and extending along the posterior margin of the propodus; the propodus very stout, about as long as the depth of the second epimeron; the breadth greatest distally, and a little less than the length; palmary margin slightly oblique, armed with a submarginal line of setæ; the middle portion a little arcuate, with an abrupt notch near the middle, and two slight emarginations near the postero-inferior angle; the dactylus stout, curved, and with the tip closing behind the angle of the propodus. In the female, the second pair of legs are slender and weak, and the carpus and hand are elongated and narrow; the propodus not broader than the merus, more than twice as long as broad; the postero-inferior angle produced distally, so that the nearly straight prehensile portion of the palmary margin forms less than a right angle with the posterior margin; the dactylus slightly curved and fitting closely the palmary margin; seventh pair of legs only slightly longer than the sixth, and with the basis broad, and its posterior margin serrate.

The infero-posterior angles of the three first segments of the abdomen a little less than right-angled, but only slightly produced. First pair of caudal stylets considerably longer than the second. Third pair short; the basal segments not reaching beyond the basal segments of the second pair, nearly as broad as long, and armed on the outside at the distal extremity with three or four stout spines; the terminal segment nearly as long as the basal, slender, tapering, and furnished

with a few slender setæ at tip. Telson stout, as long as broad; the posterior margin rounded and furnished each side with a slender seta.

Length from front of head to tip of telson, $4^{mm}.5$ to $6^{mm}.5$.]

Abundant in pools of stagnant water, New Haven, Conn. Also collected at Madison, Wis., by Professor Verrill; Madeline Island, Lake Superior, by Mr. J. W. Milner; at The Dalles, Oregon, by Mr. Oscar Harger; and in Lake Raymond and Birdwood Creek, Nebraska, by Messrs. Oscar Harger and T. M. Prudden, of the Yale College expedition of 1873; in the West Fork of the Des Moines River, Humboldt, Iowa, and at Salem, Mass., by Mr. Caleb Cooke; at Grand Rapids, Mich., and Bangor, Me., by Mr. N. Coleman; and at Norway, Me., by myself.

Since the above was in the hands of the printer, I have received numerous specimens of this species, collected at Lake Okeechobee, Florida, by Dr. Edward Palmer. In some of these specimens, the dorsal teeth upon the first and second segments of the abdomen are very small; and, in a very few specimens, they are wholly, or almost wholly, wanting.

The *Amphithoë aztecus* Saussure, (Mémoire sur divers Crustacés nouveaux du Mexique et des Antilles, p. 58, pl. 5, fig. 33, 1858,) from a reservoir at Vera Cruz, Mexico, although very badly described and figured from the male alone, has evidently no affinity with *Amphithoë* in any modern sense, undoubtedly belongs to this genus, and may be called *Hyalella azteca*. The discovery of the far southern range of our species renders it quite probable that it may prove to be synonymous with this species of Saussure.

Allorchestes Knickerbockeri of Bate, (Catalogue Amphipodus Crustacea British Museum, p. 36, pl. 6, fig. 1, 1862,) supposed to have come from the fresh waters of North America, belongs probably to this genus. It has the first and second segments of the abdomen armed dorsally as in our species, which it resembles considerably in several other respects, although the figures and description, indicated as made from the female only, represent the first pair of legs much like those of the second pair of the female of our species, while the second pair have very stout hands and resemble the second pair of legs of the male of our species. The palpus of the first pair of maxillæ, in Bate's species, is figured (perhaps incorrectly) as composed of two segments.

Family LYSIANASSIDÆ.

PONTOPOREIA HOYI, *sp. nov.* (Plate II, fig. 5.)

Pontoporeia affinis Smith, American Journal of Science, 3d series, vol. ii, p. 452, 1871; and Preliminary Report on Dredging in Lake Superior, p. 1022, 1871.
Gammarus Hoyi Stimpson, MSS., (full-grown male form.)
Gammarus brevistylis Stimpson, MSS., (female.)

On first examining specimens of this species, obtained in Lake Superior in 1871, I regarded them as specifically identical with the *Pontoporeia affinis* of the Scandinavian lakes and the Baltic. A subsequent

and more minute comparison has, however, revealed some differences, which are apparently constant. In the form and proportions of the segments of the thorax and abdomen, in the size and form of the eyes, in the minute details of antennulæ, antennæ, and mouth appendages, I can detect no differences by which it would be possible to distinguish specimens taken in Lake Superior from those sent from Lake Wetter, or from the beautiful figures of the Scandinavian species given by Sars.* In the first pair of legs, however, the propodus in the American species is proportionately a very little shorter than in the European, and the palmary margin is less oblique—that is, it is not so nearly parallel with the posterior margin; the posterior margin is somewhat shorter, and furnished with fewer hairs; and there are usually two small and slender spines on the palmary margin near the tip of the closed dactylus, while in the European species there are no real spines upon the palmary margin, but only slender setiform hairs. In both the European and American species, there is a very thin and narrow lamellar edge, extending nearly the whole length of the palmary margin. The dactylus is apparently a little longer and more slender in the European species. The obliquity of the palmary margin, and its armature near the posterior angle, seem to be always characteristic of the American species. In young specimens, however, there is often but one spine, while in larger ones there are often three. In the third and fourth pairs of legs of the American species, the dactylus is usually armed on the inside, a little way from the tip, with two setiform hairs, while in the European species there is only one. Some young specimens of the American species, however, agree with the European in having but one hair upon the dactylus, while large ones often have three, and in the full-grown male from Lake Michigan, mentioned farther on, there are even four.

The most remarkable differences are in the peculiar, elongated, papilliform appendages upon the sternal portion of the thoracic segments. In the European species, Dr. G. O. Sars describes and figures an elongated and slender process depending from the middle of the sternum of several of the thoracic segments; and in the single specimen which I have examined, there are three of these processes, one each on the second, third, and fourth segments. Dr. Sars, who has studied the living animals very carefully, does not suggest what may be the use of the appendages, or whether they ever vary in number or position in different specimens. In specimens from Lake Superior, there are usually seven of these appendages, one upon the second and two each upon the third, fourth, and fifth segments. In form and size, these appendages do not differ, except that in alcoholic specimens they seem to be a little longer in the American species. In some specimens of the American species, the appendage upon the second segment is wholly wanting, and in two specimens examined carefully there was only a single median

* Histoire Naturelle des Crustacés d'Eau Douce de Norvège, p. 82, pl. 7, figs. 10–25; pl. 8, figs. 1–5, 1867.

one upon the third segment. In the absence of all knowledge of the nature and use of these appendages, it seems useless to speculate on their importance as distinctive characters. In a species of *Pontoporeia* from the Gulf of Saint Lawrence, which I suppose to be the *P. affinis* of Kroyer, there are no such appendages on any of the thoracic segments. This fact, together with the variation noticed in the specimens from Lake Superior, would seem to indicate that these appendages are not of so much importance as might at first be supposed.

This species was found in great abundance in the dredgings in Lake Superior in 1871, and occurred in every haul from 4 to 169 fathoms. It was also dredged by Mr. J. W. Milner in Lake Superior in 1872, in 60 fathoms off Outer Island. It is common in the stomach of the white-fish from Lakes Superior and Michigan, and probably also from the lower lakes. All the specimens dredged in Lake Superior were taken in August and the early part of September, and none of the females were carrying eggs during that time. Females carrying eggs were dredged by Dr. Stimpson, in Lake Michigan, in 40 to 60 fathoms, off Racine, Wis., June 24, 1870, and with them the adult male form with long antennulæ and antennæ. This peculiar form of the adult male, corresponding perfectly with the same form of the European species figured and described by Dr. Sars, I have not been able to find among the numerous specimens from Lake Superior. A single specimen of this form of the male was, however, sent to me by Dr. Stimpson under the manuscript name of *Gammarus Hoyi*, while two specimens of the female were sent as *Gammarus brevistylis*. These are undoubtedly the same as the *Gammarius Hoyi* and *brevistilus* mentioned, without description, by Dr. P. R. Hoy, (*loc. cit.*)

PONTIPOREIA FILICORNIS, sp. nov.

Gammarus filicornis Stimpson, MSS.

Male.—Outline of the head very much as in *P. affinis*. Eyes about as large as in that species, slightly elongated, black. Peduncle of the antennula reaching nearly to the distal end of the penultimate segment of the peduncle of the antenna, about as long as the head and the first segment of the thorax together; first segment large and thickened; second half as long as the first; third slightly more than half as long as the second. Flagellum greatly elongated and very slender, reaching nearly to the tip of the abdomen, and composed of thirty-three segments, of which the proximal are longer than broad, while they increase in length distally, until, near the tip, they are many times longer than broad, and exceedingly slender. The upper side of the flagellum is nearly naked, only the alternate segments being furnished with two minute setæ near the distal extremity, while the under side of each segment is armed distally with minute setæ, and most of the segments with one or several clavate (olifactory) papillæ, and many of the segments have in addition a peculiar transparent, shallow, bell-shaped ap-

pendage, raised on a very slender peduncle. Secondary flagellum reaching to the fourth segment of the primary, and composed of four segments, of which the terminal one is very short. Penultimate segment of the peduncle of the antenna about as long as the first segment of the peduncle of the antennula; ultimate segment slightly shorter; penultimate and antepenultimate segments furnished with long, plumose hairs below and several fascicles of short, setiform hairs above. Flagellum much longer than the flagellum of the antennula, very slender, and composed of about fifty very elongated and somewhat flattened segments, which have about the same proportions as in the flagellum of the antennula, and are furnished with the same kinds of appendages.

Epimera of almost exactly the same proportions and form as in *P. affinis*, and the first four margined with plumose hairs in the same way. First pair of legs very nearly like those of *P. affinis;* the palmary margin even slightly more longitudinal than in that species, continuous with the posterior margin, and armed with two small obtuse spines near the tip of the closed dactylus in addition to the setiform hairs. Second pair of legs of the same form as in *P. affinis*, except that the palmary margin is slightly concave and a little oblique in a proximal direction; the posterior margin furnished with fascicles of setiform hairs, as in that species, and armed close to the palmary margin with three or four small obtuse spines. Third and fourth pairs of legs like those of *P. affinis*, except that the dactyli have each three setiform hairs near the tip, being in this as in several other respects nearer *P. Hoyi.* Fifth and sixth pairs of legs almost exactly as in *P. affinis*, except the posterior margin of the propodus in the sixth pair is armed with three pairs of small spines. Seventh pair of legs having a few small spines on the propodus, but otherwise as in *P. affinis.*

Lateral margins of the first, second, and third segments of the abdomen with the angles rounded; lateral margin of the third segment furnished with a line of several submarginal, plumose setæ near the anterior angle, and behind them armed with five large and acute spines directed backward, of which four are in pairs near the middle of the margin, and one alone near the posterior angle; the posterior edges of the lateral expansions of all three of the segments furnished with a few, widely separated, plumose hairs. Peduncles of the first and second pairs of caudal stylets reaching to about the same point, a little beyond the extremity of the sixth segment of the abdomen; the outer rami slightly longer than the inner, and those of the second pair of stylets only a little shorter than those of the first. Rami of the posterior caudal stylets longer than in *P. affinis;* the outer ramus rather more than twice as long as the peduncle, narrow, and tapering to an obtuse tip, both edges furnished with long plumose hairs, and the outer edge with a sharp spine at the base of each hair. Telson slightly longer than broad, cleft half-way to the base, and each lobe tipped with two short spinules and a plumose seta. There are two of the peculiar papilliform

appendages on the sternum of the third, fourth, and fifth segments of the thorax, as in *P. Hoyi*, but apparently none upon the second.

Length from the front of the head to the tip of the telson, 6 ^{mm}.

Of this species, I have seen but a single specimen, which was dredged with the last species in Lake Michigan, in 40 to 60 fathoms, off Racine, by Dr. Stimpson, from whom it was received under the manuscript name of *Gammarus filicornis.*

This species differs remarkably from all the heretofore-known species of *Pontoporeinæ*, in the excessive elongation of the flagella of the antennulæ and antennæ, a character which might be regarded by some naturalists as of generic value. The very close agreement with *P. affinis* and *Hoyi* in all other parts of the animal, however, seems to indicate a very close affinity with those species, especially the latter; and as this one peculiarity is very likely only a sexual character of the old males of the species, I retain the species in the genus. The mouth-appendages seem to agree perfectly with those of the species just mentioned. The singular armature of the lateral margins of the third segment of the abdomen is not peculiar to this species, but is almost exactly repeated in *P. affinis*, *P. Hoyi*, and the marine species, already mentioned, from the Gulf of Saint Lawrence, and is probably common to the genus, although it seems to have been overlooked till now.

Family GAMMARIDÆ.

GAMMARUS LIMNÆUS Smith. (Plate II, fig. 6, lateral view; fig. 7, dorsal view.)

> *Gammarus lacustris* Smith, American Journal of Science, 3d series, vol. ii, p, 453, 1871; and Preliminary Report on Dredging in Lake Superior, p. 1023, 1871.

Eyes small, slightly elongated. Antennulæ about as long as the thorax; first segment of the peduncle about as long as the second and third together; flagellum about twice as long as the peduncle, composed of about twenty-five elongated segments, furnished with few and minute setæ, or hairs; secondary flagellum short, scarcely, if at all, longer than the terminal segment of the peduncle, composed of two to four segments, of which the terminal one is very short. Antennæ as long as, or a little shorter than, the antennulæ; ultimate and penultimate segments of the peduncle nearly equal in length, naked above, and furnished with a few short hairs, or setæ, arranged in three or four small fascicles; flagellum considerably shorter, to nearly as long as the peduncle, composed of about twelve segments, furnished with a few short hairs.

Legs of the first pair in the male with the carpus short, triangular; the propodus a little less than twice as long as broad, much narrowed distally; the palmary margin slightly concave in outline, continuous with the posterior margin, with a narrow lamellar edge, and furnished with a few long hairs and with two ong, obtuse spines near the middle, and

three or four smaller ones on each side near the tip of the closed dactylus; the posterior margin beyond the tip of the dactylus with a few hairs and several small, obtuse spines; dactylus strongly curved and one-half as long as the propodus. In the female, the propodus is considerably smaller and proportionally shorter than in the male; the palmary margin is without the lamellar edge and without spines, except two or three long ones near the tip of the closed dactylus; and the posterior margin is armed with several shorter spines and quite numerous hairs arranged in several fascicles. Legs of the second pair in the male with the carpus a little longer than in the first pair; the propodus as long as in the first pair, slightly broadest distally, but the edges nearly parallel, and only slightly convex in outline; the palmary margin a little oblique, concave in the middle, with a broader lamellar edge than in the first pair, and armed on the outer side with a long, stout, and obtuse spine near the middle, two or three smaller ones on each side—usually two on the outer side and three on the inside—at the tip of the closed dactylus, a few short hairs along the base of the lamellar margin, and a fascicle of long hairs at the base of the median spine; the posterior margin with about six fascicles of hairs. In the female, the carpus and hand are considerably smaller than in the male; the carpus is proportionally much more elongated than in the male, and fully as broad as the pro podus; the propodus is narrow, twice as long as broad, the edges nearly parallel, the palmary margin without the lamellar edge and without the spine in the middle, straight, and very nearly transverse.

Fourth and fifth segments of the abdomen rounded above, and each armed with three fascicles of a very few small spines. Sixth segment with a fascicle of two or three spines each side, but no median fascicle. Inferior lateral margin of the first segment rounded, of the second and third produced posteriorly into an acute angle. Outer rami of the posterior caudal stylets narrow, with two or three stout spines on the proximal two-thirds of the outer edge; the inner edge without spines, and both edges furnished with long hairs; the terminal segment short, tapering, and the edges, as well as the tip, furnished with long hairs. Inner rami narrow, not quite as long as the basal portion of the outer; both edges furnished with long hairs, as in the outer rami, and the inner edge with two or three spines. Divisions of the telson about as long as the peduncles of the posterior caudal stylets, and tipped with two or three short spines and a few hairs.

Length, from the front of the head to the tip of the telson, 15^{mm} to 20^{mm}.

Color in life, uniform obscure dark brownish-green, without spots or markings of any kind.

Dredged in Lake Superior in abundance among *Cladophora*, in 8 to 13 fathoms, on the south side of Saint Ignace Island; also at Simmons's Harbor, on the north shore, in 13 to 15 fathoms; and among the Slate Islands in 4 to 6 and 12 to 14 fathoms; taken also from the stomachs of trout caught in brooks near Marquette, Mich. It is probably com-

mon in most or all the tributaries of Lake Superior, and very likely of many other of our nothern lakes and rivers.* The European species alluded to below is said, by Dr. G. O. Sars, to be the food of a variety of trout (*Salmo punctatus*) found among the higher mountains of Norway, and our species probably serves a similar purpose in the waters which it inhabits.

This species is very closely allied to the *Gammarus neglectus* of G. O. Sars,† which inhabits the lakes of Norway, and is apparently much like it in habits. Our species differs from the European in some minor details, and is undoubtedly entitled to be considered a distinct species.

The name *lacustris*, which I first gave to this species, is pre-occupied as a synonym of the European species just mentioned.

GAMMARUS FASCIATUS Say.

Journal Academy Nat. Sci. Philadelphia, vol. i, p. 374, 1817; (?)Bate, Catalogue Amphipodous Crustacea British Museum, p. 210, pl. 37, fig. 6, 1862.

Secondary flagellum of the antennulæ as long as the second segment of the peduncle, and composed of five or six segments. Antennæ furnished with many more, and much longer hairs than in the last species.

First pair of legs in the male much as in the last species; the palmary margin of the propodus armed with the stout spine on the middle of the inner side, and with two or three smaller spines near the tip of the closed dactylus much as in that species, but there are no spines on posterior margin proper. In the female, the propodus is only slightly narrowed distally, and the palmary margin is not nearly so oblique as in the male, or as in the same part of the female of the last species; the posterior margin furnished with several fascicles of hairs, but without spines, except a cluster near the tip of the closed dactylus. Second pair of legs in the male very much as in the last species, but there are three or four spines on each side—usually four on the outside and three on the inside—near the tip of the closed dactylus. In the female, the second pair of legs are very much as in the female of the last species; but the carpus and propodus are not quite so elongated.

Fourth and fifth segments of the abdomen slightly angulated dorsally at the posterior margin, and each armed with three fascicles of spines considerably larger than those in the last species, and the median fascicle on each segment raised on a distinct protuberance. Sixth segment with a median and lateral fascicles of spines. Outer rami of the posterior caudal stylets with the terminal segment very narrow, styliform, and without lateral hairs. Inner rami with usually one or two spines

* Since the above was written, I have examined specimens of this species, collected by Hayden's expedition in 1873, in Colorado, from a cool spring, Fire-Hole Basin; and very large specimens from an elevation of 9,000 feet, near Long's Peak. It was also collected the same year by Dr. Coues, while on the Northern Boundary Commission.

† Histoire Naturelle des Crustacés d'Eau Douce de Norvège, 1e livraison, p. 46, pl. 4, 5; pl. 6, fig. 1–20.

on the inner edge. Divisions of the telson with a spine and one or two hairs on the outer edge as well as a few spines and hairs at the tip.

Length, from the front of the head to the tip of the telson, 10^{mm} to 15^{mm}.

This species is probably common throughout the Northern States. It is abundant in the fresh-water streams and ponds about New Haven, Conn.; Say's specimens were from near Philadelphia; Professor Verrill has collected it at Eastport, Me.; Mr. N. Coleman, at Grand Rapids, Mich.; and Mr. J. W. Milner has found it in abundance at Ecorse, Mich. Specimens collected at Madison, Wis., by Professor Verrill, and at Waukegan, Ill., by Mr. Milner, are considerably larger than usual, and differ slightly in the number of spines upon the hands, but apparently belong to this species.

Fragments of a *Gammarus* from the stomachs of shad taken in the Delaware River appear to belong to this species.

? GAMMARUS MINUS Say.

Journal Academy Nat. Sci. Philadelphia, vol. i, p. 376, 1818; Bate, Catalogue Amphipodous Crustacea British Museum, p. 221, 1862.

I have not yet been able to rediscover this species, which is very likely not a true *Gammarus*, and, as it seems to have given rise to much confusion, I quote the original description: "Body whitish, with a few pale fulvous lateral spots; eyes reniform, blackish, placed at the exterior base of the superior antennæ; superior antennæ obviously longer than the inferior ones; seta [secondary flagellum] short, attaining the tip of the second articulation of the terminal joint [flagellum;] terminal joint with about twelve articulations. Length, three-twentieths of an inch, [nearly 4^{mm}.] Found in brooks under stones, and may be readily discovered by taking a stone out of the water, and inspecting its inferior surface."

According to Bate, specimens sent to the British Museum as this species by Say, agree in no way with the description, and are described by Bate as a species of *Allorchestes*,* although he quotes the "*Gammarus minimus* Say," of White's List of Crustacea in the British Museum under *Gammarus minus*, while White must have had the same specimens which afterward became the types of the new species of "*Allorchestes*." The *Gammarus minus* of DeKay (Natural History of New York, p. 37, pl. 9, fig. 29) is made up principally of Say's original description; but he apparently had before him some other species, (probably small specimens of *G. fasciatus*,) from which the rude attempt at a figure given in his work may have originated.

CRANGONYX GRACILIS Smith.

American Journal of Science, 3d series, vol. ii, p. 453, 1871; and Preliminary Report on Dredging in Lake Superior, p. 1022, 1871.

Female.—Eyes slightly elongated, composed of a few black facets.

* *A. Knickerbockeri.* See p. 647.

Antennulæ slightly more than half as long as the rest of the animal; first and second segments of the peduncle subequal, ultimate segment two-thirds as long as the penultimate; flagellum in full-grown specimens about once and a half as long as the peduncle, and composed of about twenty segments; secondary flagellum about as long as the basal segment of the primary flagellum, slender, and composed of only two segments, the terminal one very short. Antennæ only about half as long as the antennulæ; ultimate and penultimate segments of the peduncle elongated, subequal in length; flagellum a little shorter than the peduncle, composed of seven or eight segments. Legs of the first and second pairs subequal.

Propodus in the first pair of legs nearly quadrate in outline, a little longer than broad; palmary margin nearly straight, with a few small submarginal spines, each furnished with a cilium a little way from the tip; a similar stout spine near the posterior angle, and just at the angle itself two short, stout, obtuse, and serrated spines; dactylus stout, slightly curved, and armed with a slight tooth on the inside a little way from the tip, and with a slender, setiform hair near the middle of the outer margin. Propodus in the second pair more elongated than in the first; the palmary margin somewhat oblique, and without the short spines just at the posterior angle, but otherwise armed much as in the first pair. Fifth, sixth, and seventh pairs of legs subequal in length; posterior pair slightly longest; their squamiform basal segments with the posterior margin serrate, and both margins armed with small spines.

Postero-lateral angles of the first, second, and third segments of the abdomen produced and terminating in a small tooth. Posterior caudal stylets reaching to the tips of the penultimate; the outer rami nearly twice as long as the peduncle, and armed with a few slender spines; the inner rami rudimentary, very minute, shorter than the diameter of the outer, and wholly unarmed. Telson scarcely as long as the bases of the posterior caudal stylets, slightly broader than long, and the posterior margin with a triangular emargination, either side of which the extremity is truncate, and armed with three spines. Length, 6^{mm} to 7^{mm}.

Male.—The largest males seen from Lake Superior are considerably smaller than the females, being about 5^{mm} in length, and more slender. In the first pair of legs, the palmary margin of the propodus is slightly oblique, and armed each side with a submarginal row of about eleven stout and obtuse spines, which are nearly equidistant from one another except at the posterior angle, where about five of them are crowded together, most of the spines with a notch and cilium a little way from the tip. In the second pair of legs the propodus is proportionally shorter than in the female, and increases considerably in breadth distally, while the palmary margin is much more oblique, slightly arcuate, and armed each side with a row of about fifteen spines like those on the first pair, but not so much crowded together at the posterior angle. In other respects, the males resemble the females.

Dredged in Lake Superior, in company with *Gammarus limnæus*, among *Cladophora*, in eight to thirteen fathoms, on the south side of Saint Ignace Island.

The incubatory lamellæ of the female are very large, projecting much beyond the epimera of the anterior legs, as in *C. recurvatus* Grube, (Archiv für Naturgeschichte, vol. xxxii, p. 410, pl. 10, fig. 1,) which our species much resembles in the form of the antennulæ, antennæ, anterior legs, &c., while it differs much in the posterior caudal stylets and in the form of the telson.

A single specimen of a male *Crangonyx*, collected by Mr. J. W. Milner n an estuary of Lake Huron, belongs apparently to this species, but is very much larger, being 14^{mm} in length, so that it is quite probable that the specimens from Lake Superior are all young. This large specimen, however, agrees in all essential features with the smaller ones.

CRANGONYX VITREUS Packard.

? ? *Stygobromus vitreus* Cope, American Naturalist, vol. vi, p. 422, 1872; Third and Fourth Annual Reports of the Geological Survey of Indiana, p. 181, 1872.

Crangonyx vitreus Packard, Fifth Annual Report of the Peabody Academy of Science, Salem, p. 95, 1873.

Dr. Packard's specimens were from three different wells in Orleans, Ind., and were collected by M. N. Elrod, who says that many of them were in and on buckets that had been in the bottom of the well for several days. Professor Cope's specimens were from Mammoth Cave, Kentucky, but are described in such an unintelligible manner that it is very doubtful whether they belong to the same species, or even genus, as Dr. Packard's specimens. I have, however, followed Dr. Packard in quoting Professor Cope's name as a synonym.

CRANGONYX TENUIS, *sp. nov.*

A slender, elongated species, with very low epimera, resembling more n form the species of *Niphagus* than the typical species of *Crangonyx*.

Eyes not observable in alcoholic specimens. Secondary flagellum of the antenulæ very small, composed of two segments, of which the terminal is very short.

First and second pairs of legs differing but little in the two sexes. First pair stouter than the second, and with the palmary margin of the propodus much more oblique; the palmary margin of the propodus of both pairs, and in both sexes, armed each side with a series of stout, obtuse spines, with a notch and a cilium near the tip.

First three segments of the abdomen longer than the last three of the thorax; fourth, fifth, and sixth together scarcely longer than the third. Caudal stylets all extending to about the same point. First pair with the rami subequal, scarcely half as long as the peduncle. Peduncle in the second pair reaching a little beyond the peduncle of the first pair; the rami very unequal, the outer only half as long as the inner. Posterior pair scarcely as long as the telson; the single terminal segment very

small, and tipped with four or five setiform spinules. Telson two-thirds as broad as long, tapering very slightly toward the entire and slightly arcuate posterior margin, which is armed with about ten slender spinules.

In the largest male seen, 13mm.5 in length, (excluding the antennæ,) the antennulæ are about 5mm long; the flagellum being twice as long as the peduncle, and composed of about twenty-two segments, while the antennæ are stout, fully 6mm long, and the flagellum as long as the peduncle, and composed of fifteen segments. All the females and most of the males which I have seen are much smaller, being 6mm to 8mm in length, and in these the antennulæ are longer than the antennæ; and the flagellum of the antennulæ is composed of sixteen to nineteen segments, while that of the antennæ has only eight to ten.

The only specimens which I have seen were found in wells at Middletown, Conn., and were sent to me by Mr. G. Brown Goode.

ISOPODA.

Family Asellidæ.

Asellus communis Say. (Plate I, fig. 4.)

Journal Academy Nat. Sci. Philadelphia, vol. i, p. 427, 1818; Edwards, Hist. Nat. des Crust., vol. iii, p. 147, 1840; DeKay, Nat. Hist. New York, Crust., p. 49, 1844.
A. vulgaris? Gould, Invertebrata of Massachusetts, p. 337, 1841.

Head with the anterior margin nearly straight; external angles obliquely truncated; sides nearly parallel, with a small, prominent lobe at the posterior angle; hinder margin somewhat rounded and shorter than the anterior margin of the first thoracic segment. Eyes near the middle of the lateral margin, oval, convex, with many facets. Basal segment of the antennulæ cylindrical, much larger than the next two, which are, however, well marked as peduncular segments; flagellum nearly equaling the peduncle of the antennæ. Antennæ with three short basal segments, which are together about equal in length to the fourth; last peduncular segment equal in length to the third and fourth together; flagellum much longer than the peduncle, extending, when bent backward, about to the base of the abdomen. Both antennæ and antennulæ with scattered hairs, which are larger and stouter on the peduncular segments.

Thoracic segments increasing in breadth posteriorly; all behind the first segment with the anterior angle produced and gradually turning more and more backward in the posterior segments. Epimera becoming conspicuous on the posterior segments, which have their lateral borders emarginate and the posterior angles rounded. Pleon (abdomen) suborbicular, slightly excavated at the insertion of the caudal stylets and obtusely pointed between them, ciliate along the entire margin, as are the head and the lateral borders of the thoracic segments.

Mandibles with conspicuous triarticulate palpi, of which the first seg-

ment is clavate; the second on the external side gibbous, and furnished beyond the middle with a tuft of bristly hairs; the third slender and tapering, finely and regularly ciliate along the external side, the cilia rather suddenly increasing in length at the apex. First segment of palpus of the maxilliped short; second with the exterior margin nearly straight, interior strongly rounded and densely hairy; third subtriangular, the external margin being nearly straight, the internal much curved and converging toward the outer, the distal articulation of the segment being less than half the length of its proximal articulation; fourth segment clavate; fifth less than half the length of the fourth.

First pair of thoracic legs in the male strongly chelate; the propodus much enlarged and subglobular, with a prominent acute tooth, and a smaller lobe on its palmary margin; dactylus with a tubercle at the base, an emargination near the middle, and a small acute spine at the end; carpus small and triangular. In the remaining pairs of legs, the carpus and propodus are of about equal length and movably articulated; the posterior three are much larger than the others; and the fourth pair has a spiny tubercle on the propodus.

First abdominal segment in the males furnished with two pairs of appendages; the outer pair composed, on each side, of a small subquadrate plate, to the extremity of which is articulated another somewhat larger plate of similar shape. The inner or upper pair composed of a robust, suboval basal portion on each side, bearing at its extremity two rami; the inner ramus irregular in shape, cylindrical, bent, and tapering to a blunt extremity; outer ramus biarticulate; proximal segment short, expanding distally, and bearing a small, obtusely ovate plate, which is ciliate near the extremity. The corresponding segment in the female bears a pair of short narrow plates, which meet each other along their inner, straight margins, and are obliquely rounded and ciliate at their extremity. Outer plates of the next pair of abdominal appendages thickened, and forming an operculum for the branchiæ. These opercular plates, as taken together, are orbicular in outline, and broadly truncated at the end. Each plate is divided by a slightly oblique suture into two unequal portions; the distal portion being about twice as large as the proximal.

Posterior pleopoda, or caudal stylets, flattened, ciliate; proximal segments expanded from the base, obliquely truncated at the extremity; rami narrowly ovate, pointed, the inner about twice as long as the outer. The flattening of these appendages is more conspicuous in the adult males.

Length, excluding antennæ and caudal stylets, 15^{mm}; breadth, 5^{mm}.

Above brown, spotted, and mottled with yellowish.

This species is common under stones in streams and pools about New Haven, Conn. It is mentioned by Dr. Gould as common in Massachusetts in similar situations, and by Mr. Say in the neighborhood of Philadelphia. It has also been collected, by Mr. N. Coleman, at Grand Rapids, Mich.

ASELLOPSIS Harger.

American Journal of Science, 3d series, vol. vii, p. 601, 1874.

The genus *Asellopsis*, which was proposed for the reception of *Asellus tenax* Smith, differs from the genus *Asellus* in the *absence of mandibular palpi.* The presence of these palpi has been heretofore regarded as characteristic of the family to which both the genera undoubtedly belong.

ASELLOPSIS TENAX Harger. (Plate I, fig. 3.)

Asellus tenax Smith, American Journal of Science, 3d series, vol. ii, p. 453, 1871; and Preliminary Report on Dredging in Lake Superior, p. 1023, 1871.

Anterior margin of the head broad, excavated for the bases of the antennulæ; external angles rounded; margin expanded with a large, rounded sinus on a line with the eyes; behind this the margin expands into a rounded lobe. The posterior margin of the head is broad and rounded behind, adapted to the first thoracic segment. Eyes of more than twenty facets, considerably within the margin of the head, oval or somewhat reniform. Antennæ about half as long as the body, separated from each other at the base by about half their diameter; first three segments shorter than broad, of about equal length, successively decreasing in diameter; fourth segment as long as the first three, cylindrical; fifth or last peduncular segment as long as the third and fourth together, slender, slightly clavate; flagellum of about thirty segments. Immediately exterior to the base of the antenna is a prominent tubercle, tipped with a few short bristles. Antennulæ with the basal segments large and swollen, about equal in diameter to the fourth segment of the antennæ; second segment slender, slightly clavate, about attaining the end of the third segment of the antennæ; third or last peduncular segment small and slender, less than half the length of the second and similar to the segments of the flagellum, which are usually five in number, the second being longest.

First thoracic segment concave forward, as is also the second in a less degree; third about straight posteriorly; last four slightly curved in the opposite direction. Pleon narrowed posteriorly, obtusely rounded at the end. The margins of all the segments, as well as the pleon and the head, are ciliate; the cilia being more abundant along the external margins of the segments.

Left mandible with two dentigerous lamellæ; molar process truncated nearly at right angles; right mandible with a single dentigerous lamella; the molar process obliquely truncated. Palpus of the maxilliped with the first segment short, nearly cylindrical; second segment suborbicular, with about five cilia along the external margin and twenty along the internal. Cilia much fewer than in *A. communis;* third segment truncate-oval in outline, somewhat broader than long, ciliate; fourth segment cylindrical, or somewhat clavate, less than half the diameter of the third; fifth or last segment about half as long as the penultimate.

First pair of thoracic legs chelate; carpus small, triangular, and closely united with the propodus, which is thickened in the male, with a broad, low tubercle on the inner margin a little above the base; dactylus more than half as long as the propodus, its palmary edge armed with spines, of which the distal ones are the larger, and at the end with a large spine; carpus and propodus in the remaining six pairs of legs of about equal length, movably articulated, and armed with acute spines along their posterior edges; dactylus much less than half as long as the propodus, armed with spines along the posterior margin, and biunguiculate at tip. Three proximal segments similar in all the legs, the first being longest, and the third short and triangular, or quadrant-shaped.

The first abdominal segment is furnished, in the males, with two pairs of appendages, of which the outer is composed of a small oval plate, with a few articulated spines along the inner border, and articulated at its extremity with a larger and longer plate, which is expanded along its outer border, and ciliate along its exterior and distal margin. The inner or upper pair of appendages consists, on each side, of a robust quadrate plate, to the distal margin of which two biarticulate rami are attached. The inner ramus has its proximal segment short, much expanded, but not in the form of a hook, as in *A. aquaticus* as figured by Sars;* its terminal segment is pear-shaped, as in that species. The outer ramus has its proximal segment also expanded and triangular; the distal segment quadrate and ciliate externally and distally. The corresponding abdominal segment, in the females, with a single pair of plates, which are subquadrant-shaped but broader than long, with their inner margins straight and meeting each other on the median line. Outer plates of the next pair of abdominal appendages thickened, and forming an operculum covering the remaining branchial plates. These opercular plates are semi-ovate, truncated at the extremity, straight on the inner side, and meet along the median line. They are each divided into two very unequal portions by a suture, running from near the end of the inner straight margin, diagonally across the plate, to a point on the outer curved margin about one-third of the way from the base to the apex; the distal portion is thus much the smaller.

Posterior pleopoda, or caudal stylets, slender; proximal segment somewhat larger than the fourth segment of the antennæ, cylindrical, as are the two rami, of which the outer is only half as long as the inner.

Length, excluding antennæ and caudal stylets, 8^{mm} to 13^{mm}.

Color above dark-fuscous, spotted, and mottled with yellowish.

Common among *Cladophora*, in 8 to 13 fathoms, on the south side of the island of Saint Ignace, also in 4 to 6 fathoms at the eastern end of that island, and in 6 to 8 fathoms among the Slate Islands in Lake Superior; and since collected by Mr. J. W. Milner on algæ drifted into nets, 30 fathoms, Thunder Bay, Lake Huron.

* Histoire Naturelle des Crustacés d'Eau Douce de Norvège, 1e livraison, pl. x, fig. 6, 1867.

Mr. Milner has also collected at Ecorse, Mich., on the Detroit River, specimens probably of this species, but differing from the form above described as follows: The flagellum of the antennulæ contains one or two more segments. The lateral portions of the head and segments of the body, especially in fully adult specimens, are expanded so that the outline of the animal is a broader oval. The open sinus in the lateral margin of the head is a narrow incision, rounded at the bottom, but with the sides sometimes meeting. The propodus in the first pair of legs is nearly as much enlarged in the males as in *A. communis*, and is armed on its palmary margin with three acute teeth, of which the middle one is the largest.

I propose the variety-name *dilata* for this form, although inclined to regard it as the more typical form of the species, which was, however, first described from the less perfectly developed specimens found in Lake Superior.

CÆCIDOTEA STYGIA Packard.

American Naturalist, vol. v, p. 751, figs. 132, 133, 1871; Fifth Annual Report Peabody Academy of Science, Salem, p. 95, 1873.

Cæcidotea microcephala Cope, American Naturalist, vol. vi, p. 411, figs. 109, 110, p. 419, 1872, and reprinted in Third and Fourth Annual Reports of the Geological Survey of Indiana, p. 163, 1872, (*teste* Packard;) Smith, American Naturalist, vol. vii, p. 244, 1873.

Found in Mammoth Cave, Kentucky; Wyandotte Cave, Indiana; and from wells at Orleans, Ind.

I have had no specimens of this species for examination, but, as Professor Packard suggests in his last paper, it is evidently very closely allied to *Asellus*, and has no affinity with *Idotea*. Professor Packard was at first misled by having only a single specimen and that one having lost the caudal stylets. Professor Cope figures and describes his specimens as having external "egg-sacs" attached to the tip of the abdomen. These egg-sacs undoubtedly really belonged to some *Entomostracan*, and probably to the parasite of the blind fish from the same cave. Professor Packard says they were the caudal stylets mistaken for egg-sacs by Professor Cope, but this seems impossible, as they are figured and described as short, broad sacs filled with spherical bodies.

B—THE CRUSTACEAN PARASITES OF THE FRESH-WATER FISHES OF THE UNITED STATES.

Scarcely anything has as yet been published upon the crustacean parasites infesting our fresh-water fishes, and the principal object of the following partial synopsis is to call attention to the subject, and furnish a basis for future investigation, which is of special practical importance to all those engaged in raising fishes confined in ponds or other restricted areas.

The few species here enumerated are doubtless only a small fraction

of those which really prey upon our common fishes. The species are usually not conspicuous, and are very likely to be overlooked by ordinary observers. The Lernæans, which include the commonest and by far the most injurious species, may be attached to any part of the fish, and should be specially looked for upon the gills and about the gill-openings and throat. It is important that specimens should be collected in large numbers for study. For this purpose, they should be preserved, while quite fresh, in small bottles of alcohol or other strong spirit.

Family ARGULIDÆ.

ARGULUS CATOSTOMI Dana and Herrick.

American Journal of Science, 1st series, vol. xxx, p. 388, 1836, and vol. xxxi, p. 297, plate, 1837.

Parasitic on the "sucker," a species of *Catostomus*, in Mill River, near New Haven, Conn., in both fresh and brackish water.

Argulus Funduli Kroyer, (Bidrag til Kundskab om Snyltekrebsene, p. 20, pl. 2, fig. 1, 1863,) should, perhaps, be included in this list, as it is described as found upon *Fundulus limbatus* Kroyer, from New Orleans, but it is not stated whether from salt or fresh water.

Family CALIGIDÆ.

LEPEOPHTHEIRUS SALMONIS Kroyer.

Caligus Salmonis Kroyer, Naturhistorisk Tidsskrift, vol. i, p. 622, 1837, vol. ii p. 13, 18, pl. 6, fig. 7, 1838; Edwards, Hist. Nat. des Crustacés, vol. iii, p. 455; Steenstrup and Lütken, Bidrag til Kundskab om det aabne Havs Snyltekrebs og Lernæer, p. 15, 1861.

Caligus vespa Edwards, op. cit., vol. iii, p. 456.

Lepeoptheirus Stromii Baird, British Entomostraca, p. 274, pl. 32, figs. 8, 9, 1850.

Lepeophtheirus Salmonis Kroyer, Bidrag til Kundskab om Snyltekrebsene, p. 137, pl. 17, fig. 1, in Naturhistorisk Tidsskrift, III, vol. ii, 1863.

Parasitic on the salmon of our eastern coast and of Europe. It is perhaps more properly a marine than a fresh-water species, but is carried by the salmon far up the fresh water rivers.

Ergasilus Funduli Kroyer, (Bidrag til Kundskab om Snyltekrebsene, pp. 228, 238, pl. 11, fig. 1, 1863,) from *Fundulus limbatus* Kroyer, from New Orleans, is perhaps to be added to this list.

Family LERNÆOPODIDÆ.

ACHTHERES PIMELODI Kroyer.

Bidrag til Kundskab om Snyltekrebsene, pp. 272, 275, pl. 17, fig. 5, 1863.

Upon a specimen of *Pimelodus maculatus*, from Cincinnati, according to Kroyer, from whose work I translate the following diagnosis: "Arms, by which the animal is attached, much longer than the head, slender, nearly straight; bulla (the extremity of the united arms) very small, sessile. Body annulated into five segments, and marked with two dorsal, longitudinal sulcations. External ovaries equaling or exceeding the

length of the animal, slender, linear, provided with about twenty series of eggs longitudinally, and two, or at the most three, transversely."

ACHTHERES LACÆ Kroyer.

Op. cit., pp. 274, 275, pl. 17, fig. 6, 1863

This species is described by Kroyer from a "North-American species of perch, (*Perca Laca*,)" and should probably be included in this list. The following is a translation of the diagnosis: "Arms, by which the animal is attached, scarcely or a little longer than the head, stout, arcuate; bulla distinctly petiolate. Body neither annulated nor longitudinally sulcated; external ovaries much shorter than the animal, about equaling the body; stout, obclavate, filled with about twelve series of eggs longitudinally, and transversely, with four anteriorly, three in the middle, and two posteriorly."

LERNÆOPODA FONTINALIS, *sp. nov.* (Plate III, fig. 12, lateral and dorsal views; figs. 13 and 14, details.)

Female.—Head nearly as long as the body, and longer than broad. Body, short and thick, not very much longer than broad. Prehensile hooks (fig. 14, *a*) stout, nearly half as long as the head, with a small papilliform process on the inside of the penultimate segment; terminal segment rather slender, tapering, straight to near the tip, which is suddenly curved backward, and terminating in an acute point. Arms by which the animal is attached nearly or quite as long as the body; bulla with an elongated petiole, and broadly expanded at the extremity; ova-sacs as long as or a little longer than the body, with three or four series of eggs transversely, and ten to twenty longitudinally.

Entire length, from mouth to extremities of ova-sacs, 5^{mm}; diameter of body, $1^{mm}.5$; length of ova-sacs, 2^{mm}; diameter of ova-sacs, $0^{mm}.75$.

This species is apparently allied to the *L. carpionis* of Kroyer, (op. cit., p. 277, pl. 14, fig. 4,) and seems to belong to this genus as understood by Kroyer. In our species, the antennulæ (fig. 13, *c*) are very short and small processes, not reaching beyond the mouth. The antennæ (fig. 13, *d*) are large, and extend as far forward as the mouth, and each one is divided at the extremity into three lobes, of which the median lobe is again minutely bilobed, or obscurely forcipulate, while the lateral ones (dorsal and ventral in relation to the animal) are armed with numerous minute hooks, and on the outer side, just below the tip, there is another similar lobe armed with minute hooks. The palpi-like appendages (fig. 13, *b*) on each, just below the mouth, are each tipped with three papilla-like lobes. The mandibles (fig. 14, *b*) are each armed with four stout distal and three much smaller proximal teeth.

Found upon the brook-trout, (*Salmo fontinalis*,) at Norway, Me., in the trout-breeding establishment of Mr. A. B. Crockett. The specimens were all attached to the gills, and were apparently the cause of the

death of the fish on which they were found. It is probably a common and widely-distributed species.

I have considerable hesitation in referring this and the next species to the genus *Lernæopoda*, which is usually restricted to parasites of marine or partially marine fishes. Our species certainly do not agree generically with the typical species of *Achtheres*, described and figured by Nordmann, while they seem to agree very well with species of *Lernæopoda* described by Kroyer. It is possible our species may belong to *Basanistes*, but in all external characters they seem to differ widely. In fact, the species of this group have many of them been so poorly described that it is very difficult to make out what the characters of genera really are. The European species, upon which most of the genera are based, need careful revision.

LERNÆOPODA SISCOWET, *sp. nov.* (Plate III, fig. 15, fig. 16, details.)

Female.—Head not more than half as long as the body. Body short, but little longer than wide, semi-annulated by three or four obscure constrictions on the ventral side, and the posterior extremity extending only slightly beyond the bases of the ova-sacs. Prehensile maxillipeds fig. 16, *b*) proportionally smaller than in the last species; the penultimate segment with a process upon the inside terminated by two small, papilla-like appendages, (fig. 16, *b′*;) the terminal segment regularly curved from the base to the acute tip, and armed on the under side near the tip with a spinous prominence. Arms about as long or considerably longer than the body, slender, nearly straight; bulla with a distinct petiole and a broadly-expanded margin. Ova-sacs longer than the head and body together, linear, with twenty to thirty longitudinal and about four transverse series of eggs.

The antennulæ are a little longer than in the last species, and the antennæ and palpi are quite similar to the antennæ and palpi of that species. The mandible, (fig. 16, *a*,) on one side, at least, is broad toward the base, and is armed with four stout distal, and one, or possibly two, small proximal teeth.

Entire length of a specimen, from mouth to extremities of ova-sacs, 13^{mm}; length of body, 5^{mm}; diameter of body, $3^{mm}.2$; length of ova-sacs, $8^{mm}.3$; diameter of ova-sacs, $1^{mm}.2$.

This species was found upon the siscowet (*Salmo siscowet*) at Outer Island, Lake Superior, by Mr. J. W. Milner.

LERNÆOPODA (?) COREGONI, *sp. nov.* (Plate III, fig. 17.)

Head more elongated than in the preceding species. Body elongated and with some obscure indications of annulation, due perhaps to contraction in alcoholic specimens. The prehensile maxillipeds (fig. 17, *a*) reaching nearly as far forward as the mouth; the basal portion very stout; the terminal portion slender, cylindrical, flexible, and armed at the extremity with a minute, strongly-curved hook, (fig. 17, *a′*.) Arms slender, but shorter than the body; the bulla with

a short but distinct petiole. Ova sacs nearly as long as or considerably longer than the body, linear, with three or four transverse and eighteen to thirty-five longitudinal series of eggs.

The antennulæ are much longer than in the species just described, extending fully as far forward as the mouth. The antennæ are proportionally rather larger than in either of the species here described, but are similar to them in structure. The palpi are small, and each one is terminated by two minute, papilla-like appendages. The mandibles (fig. 17, *b*, *c*) each have four stout distal teeth, besides a smaller terminal one, which is nearly obsolete on one mandible and conspicuous on the other, and three small proximal teeth on one and two on the other.

Entire length of a specimen, from mouth to extremities of ova-sacs, 13^{mm}; length of body, $5^{mm}.5$; diameter of body, $1^{mm}.8$; length of ova-sacs, 6^{mm}; diameter of ova-sacs, 1^{mm}.

Found by Mr. J. W. Milner on the white-fish (*Coregonus albus*) at Ecorse, Mich., and at Outer Island, Lake Superior.

This species is probably not a true *Lernæopoda*, and is perhaps the representative of an undescribed genus.

CAULOXENUS STYGIUS Cope.

Proceedings Academy Nat. Sci. Philadelphia, 1871, p. 297; American Naturalist vol. vi, pp. 420, 412, figs. 111–113, 1872, and reprinted in Third and Fourth Annual Reports of the Geological Survey of Indiana, pp. 175, 164, 1872; Packard Fifth Annual Report Peabody Academy of Science, Salem, p. 94, 1873.

This is a peculiar lernæan, described by Professor Cope as parasitic on the blind fish (*Amblyopsis*) of Wyandotte Cave, Indiana; also from a cave in Bradford, Orleans County, Ind., according to Professor Packard. According to Professor Cope, it is allied to *Achtheres* and *Lernæopoda*, although the arms by which the animal is attached are united for their whole length, and it is stated that it "is not a sucker or devourer of its host, but must feed on the substances which are caught by the blind fish and crushed between its teeth"!

Family LERNÆOCERIDÆ.

LERNÆOCERA CRUCIATA Lesueur.

Lerneocera cruciata Lesueur, Journal Academy Nat. Sci. Philadelphia, vol. iii, 286, pl. 11, fig. 4, 1824; Edwards, Hist. Nat. des Crustacés, vol. iii, p 527.
Lernea cruciata DeKay, Nat. Hist. of New York, Crustacea, p. 59, 1844.

On *Centrarchus æneus* in Lake Erie, according to Lesueur.

LERNÆOCERA CATOSTOMI Kroyer.

Bidrag til Kundskab om Snyltekrebsene, p. 321, pl. 18, fig. 4, 1863.

Described by Kroyer as found in the Mississippi River, at Saint Louis, on *Catostomus macrolepidotus*, and so is very likely to be found much farther north and east.

Another species is described by Kroyer, (*L. Pomotidis*, op. cit., p. 323, pl. 15, fig. 5,) from a species of *Pomotis* taken at New Orleans.

XXVI.—SYNOPSIS OF THE NORTH AMERICAN FRESH-WATER LEECHES.

By A. E. Verrill.

The leeches are related to the fisheries in three ways. Some of the large blood-sucking species, like *Macrobdella decora* and the species of *Hirudo*, attack many fishes directly, even when of considerable size, and destroy them very quickly by sucking their blood; and the species of *Icthyobdella* and *Cystobranchus* are true parasites of fishes, and often, when numerous, do them much injury. Other kinds, like the various species of *Clepsine*, *Nephelis*, *Aulastomum*, &c., destroy all sorts of small mollusks and worms, which otherwise might become the food of fishes. But, on the other hand, certain kinds of leeches are fed upon, to some extent, by the lake white-fish and probably by other fishes.

In a paper published in February, 1872, I gave a synopsis of all the North American fresh-water leeches then known to me. Since that time, however, I have had opportunities to examine numerous living specimens of most of the described species, and have been able to study the variations more fully, and thus to improve many of the descriptions. A few new species and marked varieties have also been added to the list. I have also had opportunities to examine the various collections of leeches obtained from the great lakes by Mr. J. W. Milner while engaged in the investigation of the fisheries; by Mr. Oscar Harger and Mr. T. M. Prudden while on the Yale scientific expeditions to the Rocky Mountains in 1871 and 1873; by Dr. Josiah Curtis, Dr. H. C. Yarrow, and H. W. Henshaw, while on the surveys west of the one-hundredth meridian, under Lieutenant Wheeler; by Dr. Elliott Coues, on the northwest-boundary commission; and by Dr. Hayden's expeditions. These collections have afforded many facts of great interest in relation to the geographical distribution of the species, although they have added but few new forms to those previously known.

In order to facilitate the identification of the genera, the following artificial key has been prepared. It is intended to apply only to the genera included in the present paper.

Analytical key to the genera of American leeches described in the following article.

a. Head tapering, continuous with the body, (*b*:)
a a. Head dilated; neck constricted, (*h*:)
b. Ocelli marginal in a curved line; no proboscis, (*c*:)

b b. Ocelli in one to four pairs along the median line; an exsertile proboscis................ *Clepsine*, (p. 677.)
b b b. Ocelli none; no proboscis .... *Liostomum*, (p. 688.)
c. Œsophagus with folds, and armed with three convergent jaws, (*d*:)
c c. Œsophagus with folds; no jaws, (*f*:)
d. Jaws with denticles, (*e*:)
d d. Jaws without denticles .... *Democedes*, (p. 671.)
e. Œsophagus with 9 folds; jaws prominent.. *Macrobdella*, (p. 667.)
e e. Œsophagus with 12 folds; jaws small...... *Aulastomum*, (p. 670.)
e e e. Œsophagus with 6 folds; jaws broad...... *Hirudo*, (p. 688.)
f. Folds, 12; 3 transverse lobes; ocelli, 8 or 10. *Semiscolex*, (p. 671.)
f f. Folds, 6; 3 transverse lobes; ocelli, 10.... *Hexabdella*, (p. 672.)
f f f. Folds, 3; no transverse lobes; ocelli, 6 or 8, (*g*:)
g. Body distinctly dilated and flat posteriorly; ocelli, 8 .... *Nephelopsis*, (p. 673.)
g g. Body not much dilated posteriorly; sub-depressed; ocelli, 6 or 8.................... *Nephelis*, (p. 675.)
h. Body subterete; no lateral appendages, (*i*:)
h h. Body somewhat depressed; a row of pulsating vesicles along each side............... *Cystobranchus*, (p. 685.)
i. Head obliquely attached, dilated; margins not fringed............................. *Ichthyobdella*, (p. 686.)
i i. Head campanulate; margin fringed with minute bristles .... *Astacobdella*, (p. 688.)

MACROBDELLA Verrill.

American Journal of Science, vol. iii, p. 137, 1872.

Body strongly annulated, stout, broad, depressed throughout, tapering but little. Cephalic lobe large, rounded in front, composed of five segments, its lower surface rugose with longitudinal sulcations, and at the base having a transverse fold, which forms sockets for the protection of the maxillæ when retracted. Maxillæ three, stout, and prominent, the outer edge denticulate, with numerous acute teeth. Nine plications within the œsophagus. Stomach voluminous, divided into several compartments, with very large and irregular dilations or pouches on each side. Ocelli 10. Male orifice of the typical species in the twenty-seventh* segment behind the mouth; vulva between the thirty-first and thirty-second. Anal opening dorsal, in advance of the posterior sucker.

This genus has a remarkable combination of the characters of several diverse genera. It has, like *Bdella*, sulcations on the cephalic lobe beneath; maxillæ similar to those of *Hirudo*, but more prominent; a plicated œsophagus, similar to that of *Aulastomum;* a stomach most

* Leidy says that the male orifice perforates the twenty-fifth annulus, but he apparently excludes the buccal segment from his count.

like that of *Hæmopis;* internal reproductive organs similar to those of *Hirudo;* while the external male organ is more like that of *Hæmopis.* The genus differs from all the others, however, in the situation of the genital orifices, in the form of the maxillæ, the number of plications in the œsophagus, &c. It includes one of the stoutest, largest, and most powerful of the leeches hitherto described.

MACROBDELLA DECORA Verrill.

American Journal of Science, vol. iii, p. 138, fig. 4, February, 1872.

Hirudo decora Say, Long's Second Expedition, vol. ii, p. 268, 1824; Diesing, Systema Helm., i, p. 474; Leidy, Proc. Phil. Acad. Nat. Sci., 1868, p. 230.

Body large, stout, broad, considerably depressed throughout; in extension much elongated, and gradually tapering anteriorly; strongly annulated. Length of the larger specimens twelve inches or more; greatest breadth upward of an inch. Head rounded in front, the cephalic lobe capable of considerable dilation, consisting, apparently, of five segments. Ocelli, 10: the first pair between the second and third segments; the second on the third; the third on the fourth; the fourth pair on the sixth, or buccal; and the fifth on the ninth segment, or fourth behind the mouth. Cephalic lobe rugose and wrinkled beneath, and with conspicuous longitudinal sulcations, of which three, corresponding with the maxillæ, are deepest; posteriorly with a conspicuous semicircular fold, surrounding and partially concealing the maxillæ when retracted into their fossæ. Maxillæ thick, very prominent, higher than broad; outer edge rounded in front, and finely and closely denticulate. Below each maxilla, in the œsophagus, is a broad plication or fold, which often divides into two a short distance beyond; alternating with these are three simple narrower folds, making six or nine in all. External male organ prominent, stout, conical; the broad wrinkled base rising from the twenty-fourth to the thirtieth segments; the terminal portion smoother, with six sulcations; the orifice small, with six lobes, opening in the twenty-seventh segment. Female orifice also with small lobes, surrounded by a slightly elevated area, formed upon the thirty-first and thirty-second segments; posterior to these, there are four conspicuous rugose elevations in a quadrangle on the thirty-sixth to the thirty-eighth segment, and smaller ones on the thirty-ninth segment, with less marked ones on two or three of the previous and following segments; corresponding to these rugosities, there are well developed internal glands.

The reproductive organs are here described from preserved specimens, of large size, taken in the breeding season, in spring. At other seasons, and in smaller specimens, these characters are not so obvious. Acetabulum large, separated from the body by a well marked constriction.

Color above, dark livid brown, or olive-green, with a median dorsal row of about 20 to 22 bright or pale red spots, which are sometimes obsolete, and a row of rounded black spots near each margin, corresponding in number, and nearly in size, with the red ones. Lower sur-

face bright or dark orange-red, or reddish brown, sometimes with black spots near the margins.

This species is very common, and widely diffused in the fresh waters of the Northern United States. Its range northward and southward is unknown. It is the only true blood-sucking leech known to me from the Northern States. It is capable of drawing blood from the human skin, but ordinarily subsists upon fishes, frogs, and tadpoles. It often attaches itself to the throat, and speedily kills them, even when of considerable size. It is frequently used instead of the imported leeches by physicians, and is equally efficacious.

Vermilion River—Say; Norway, Me.; in many lakes and streams in other parts of Maine; and in streams and ponds near New Haven—A. E. Verrill; Minnesota—Dr. Leidy; Madeline Island, Lake Superior—J. W. Milner; Smoky River, Kansas—O. Harger.

Subgenus PHILOBDELLA Verrill.

The remarkable characters of the reproductive organs in the following species entitle it to at least subgeneric rank. The jaws also differ considerably from those of the preceding species, and it may be hereafter necessary to make it a distinct genus.

MACROBDELLA FLORIDANA Verrill, *sp. nov.*

Body much depressed, except near the head; in preserved specimens about 1.5 inches long and 0.28 of an inch wide. Ocelli, ten, small; the first two pairs are near together, on the front of head, apparently on the first segment; the third pair is on the second segment; the fourth is on the fourth; and the fifth pair is on the seventh segment, or fourth posterior to the mouth. The anterior lip is, in the preserved specimens, short, broadly rounded, and incurved; the lower surface longitudinally sulcated, with a thin, elevated, transverse fold posteriorly, in advance of the jaws, behind which they can be retracted. Jaws, or maxillæ, small, but prominent, about as thick as broad, scarcely compressed, except close to the blunt edge, which is armed with about twenty acute teeth. Œsophagus with nine distinct folds, some of which are occasionally partially divided posteriorly. Acetabulum rather small. In ordinary specimens, the visible external reproductive organs consist of a small orifice (male?) between the twenty-eighth and twenty-ninth segments; and an elevated conical papilla (female?) arising from the twenty-ninth and thirtieth segments, and followed by about three pit-like depressions. But two specimens, taken and preserved while *in coitu*, have an entirely different appearance. In these, there is a large orifice, probably the true male opening, apparently in the twenty-eighth segment behind the mouth. Just in front of this, on the twenty-sixth and twenty-seventh segments, there are two small lunate, median pits or openings, with raised borders; and just behind it, on the twenty-ninth segment, there is a larger transversely-bilobed orifice, or deep pit. These four openings are surrounded by a raised area, somewhat circular in form, on

which there are several small raised verrucæ, five or six on each side of the median line. The parts described appear to belong to the male system of organs, and have their exact counterparts in the female system of organs farther back. These consist of a large, obtuse, prominent central papilla, at about the thirty-first segment, having what appears to be the true female orifice at its concave summit; just posterior to this, there are two slender, median papillæ, bilobed at the end, corresponding in size and form with the two pits in front of the male orifice; just in advance of the large papilla, on the thirtieth segment, there is a shorter, transversely-bilobed papilla, agreeing in form and size with the pit just behind the large central male orifice. These female organs are also surrounded by a swollen area, on which there are several small rounded depressions, corresponding in size and number to the small verrucæ on the male area. The two specimens are alike in all these arrangements, and were firmly united, head to head, by means of the organs, which were inserted into the corresponding sockets, which act, therefore, somewhat like suckers, and serve to securely hold the two individuals in the proper position.

Color, in alcohol, dark brownish above, with two faint bands of reddish brown along each side toward the margin, separated by a narrow line of blackish; margins and ventral side dull reddish brown.

Lake Okechobee, Florida—Dr. Edward Palmer. One specimen, when preserved, was engaged in swallowing a small lumbricoid worm.

AULASTOMUM LACUSTRE Leidy.

Proceedings Acad. Nat. Sciences of Philadelphia for 1868, p. 229; Verrill, American Journal of Science, vol. iii, p. 135, 1872.

This species, as described by Dr. Leidy, has 10 ocelli; 8 in the upper lip, the last pair separated by an annulus from the others. Male aperture in the twenty-fourth annulus; female orifice in the twenty-ninth. Œsophagus capacious, with twelve folds. "Jaws thin, small, when at rest included in pouches formed by an eversion of the mucous membrane. Teeth, 12 in number to each jaw, bilobed at base." Color (var. *a*) throughout olive green, closely maculated everywhere with confluent spots of a darker hue of the same color. When full-grown, this species becomes 6 to 8 inches or more long and half an inch broad.

Var. b, *tigris*.—Large and broad, depressed. Color yellowish green to dark olive-green, with scattered irregular blackish spots and blotches.

Var. c, *fuliginosum*.—Color uniform dusky or brownish black.

Var. d, *virescens*.—Color uniform greenish, or yellowish green, varying to dark green; usually paler beneath.

In my specimens, the male organ is long, very slender, thread-like, and is protruded from an opening in the twenty-fifth segment, behind the mouth, (counting the buccal segment.) The female orifice is small, with slightly raised borders, and is situated between the twenty-ninth and thirtieth segments. The fourth pair of ocelli is on the buccal segment; and the fifth pair is on the third segment behind the mouth.

Var. *a*, Twin Lake, Minnesota, and Lake Superior—Leidy; Denver, Col.—Mr. Henshaw, Wheeler expedition, 1872; Yellowstone Lake and Yellowstone River, abundant—Dr. J. Curtis, Wheeler expedition, August, 1872; between Santa Fé and Wingate, New Mexico—Dr. Loew, Wheeler expedition; New Haven—A. E. Verrill.

Var. *b*, Lake Superior—Leidy; Fairfield, Utah—Dr. Yarrow, Wheeler's expedition; Utah, in a tributary of Great Salt Lake—Mr. Gorman; Cool Spring, Fire-Hole Basin—No. 224, Collection Smithsonian Institution.

Var. *c*, New Haven—A. E. Verrill; lake near Long's Peak, elevated 9,000 feet—Hayden's expedition.

Var. *d*, Springs, Saguache, Colorado—Ernest Ingersoll, Hayden's expedition, (also var. *b*.)

DEMOCEDES Kinberg.

Ofversigt af Kongl. Vet. Akad. Förhandlingar, xxiii, p. 356, 1867; Verrill, op. cit., p. 137, 1872.

This genus, according to Kinberg, has "three muscular, compressed, edentate maxillæ," with the habit of *Hirudo*. The two species first named by him are from Port Natal, and have 10 ocelli. The remaining species has but 8 ocelli, and is described as follows:

DEMOCEDES MACULATUS Kinberg.

Op. cit., p. 356; Verrill, loc. cit., p. 137, 1872.

Body tuberculose, with minute tubercles, cinereous, with irregular black and white spots; cephalic lobe 5- or 6-annulate; ocelli 8; fourth pair on the buccal segment; abdominal orifices in the twenty-fifth and thirtieth segments; segments, 94; length, 88^{mm}.

Wisconsin—Kumlin.

SEMISCOLEX Kinberg.

Op. cit., p. 357, 1867; Verrill, Amer. Journ. Science, vol. iii, p. 136, 1872.

According to Kinberg, this genus has the following characters: maxillæ wanting; pharynx with a transverse sulcus below the posterior margin of the buccal segment, and below that provided with longitudinal sulci; habit of *Hirudo*.

SEMISCOLEX JUVENILIS Kinberg.

Op. cit., p. 357; Verrill, loc. cit., p. 136.

This, the typical species, has a smooth body, with a narrow median dorsal fascia, and a series of spots on each side. Cephalic lobe a little elongated, three-annulate; ocelli eight, with the fourth pair on the second segment of the body; abdominal orifice in the twenty-sixth segment; segments, 97; length, 40^{mm}.

Montevideo, in fresh water.

SEMISCOLEX GRANDIS Verrill, *sp. nov.*

Body very large, broad, stout, with about 90 well marked annulations, forming crenulations along the margins; length, in full extension, 10 to 12 inches or more; greatest breadth, 1 to 1.25 inches. Head somewhat prolonged and tapered, composed of several distinct annulations. Ocelli, 10: the first pair near together on the first annulus of the head; the second pair on the second annulus; the third pair on the third annulus; the fourth pair on the fifth annulus; and the fifth pair on the eighth annulus. Upper lip divided beneath into two median and two lateral areas by three deep, triangular fossæ; each of these areas is subdivided by numerous longitudinal and transverse wrinkles, the small interspaces being rather smooth; the lip is separated from the opening of the œsophagus by a deep transverse groove, bordered below by a membrane, which rises into three tranverse folds or lobes, but these are often rather indistinct in preserved specimens. Œsophagus relatively small and short, with about twelve unequal plications or folds, some of which are often indistinct, or united anteriorly, and sometimes with additional small ones intercalated between the larger ones posteriorly. No distinct maxillæ could be detected. Male orifice situated between the twenty-fourth and twenty-fifth annuli behind the mouth; female orifice in the thirtieth annulus. The male orifice is in a small, circular pit, from which, in one specimen, a long, filiform, intromittent organ is extended to a distance equal to half the breadth of the body, or about 0.5 of an inch, (11^{mm}.) The female orifice is transversely elliptical, with slightly raised and rugose margins. Acetabulum small and deep, projecting less than half its diameter beyond the end of the body. Anal orifice large, surrounded by numerous convergent plicæ.

Color dusky brown above, somewhat paler beneath, sometimes with a few rather large, roundish, but irregular, distantly scattered dark spots on the back, and often with two or three beneath; sometimes nearly uniform slate-brown, with only a few, small, remote blackish spots.

Var. b, maculatus.—Form and size as in the preceding variety. Color above olive-green or yellowish green, thickly spotted with irregular angular, more or less confluent, blotches of blackish. The folds of the œsophagus, in the single specimen examined, consist of three broad ones, imperfectly and rather indistinctly divided into three subplicæ; alternating with the three broad folds were three narrow and inconspicuous ones.

Var. *a*, West River, New Haven, Conn.—A. E. Verrill; Lake Huron, at Au Sable, Michigan.—J. W. Milner.

Var. *b*, Madeline Island, Lake Superior—J. W. Milner.

HEXABDELLA Verrill.

Op. cit., vol. iii, p. 136, 1872.

Body depressed posteriorly. Cephalic lobe prolonged, composed of four segments, with three longitudinal folds beneath, followed by three transverse fleshy lobes, or folds; below these, the œsophagus is fur-

nished with six longitudinal plications. Ocelli, ten: the fourth pair on the buccal segment; the fifth on the second segment behind the buccal. Anus dorsal, at the posterior end of the body. Acetabulum round, separated from the body by a deep constriction.

This genus, although evidently allied to *Semiscolex*, differs in the structure of the cephalic lobe and œsophagus.

HEXABDELLA DEPRESSA Verrill.

Op. cit., vol. iii, p. 136, 1872.

Body strongly annulated, broad and much flattened posterior to the clitellus, tapering and somewhat rounded in front of it. Length, in partial contraction, 1.50 inches; breadth 0.40 inch. Head, or cephalic lobe, somewhat elongated, rounded in front, with four annulations, the first or terminal one oval, separated from the following by a decided depression, or fossa. Ocelli, ten: the first pair near together on the posterior edge of the first cephalic segment; the second pair, on the second, and the third, on the third segment, form a nearly regularly curved line; those of the fourth pair are on the sides of the fifth or buccal segment; and those of the fifth are on the seventh segment, or the third of the body. Cephalic lobe divided beneath into three broad lobes by two deep sulcations, each lobe subdivided into smaller ones by less marked, divergent grooves. Behind each of the three lobes, there is an elevated, transverse, rounded, fleshy lobe, or fold; behind these, and separated by a deep groove, there are six well marked plications in the œsophagus. Anus with elevated, crenulate borders. Male organ between the twenty-fourth and twenty-fifth segments of the body. Acetabulum round, of moderate size. Color of the preserved specimen, dark slate-brown above, with few irregularly scattered, remote black spots, and with still fewer small, white specks; beneath, lighter slate-brown, with very few black spots toward the margins.

Near New Haven, Connecticut—A. E. Verrill.

NEPHELOPSIS Verrill.

American Journal of Science, vol. iii, p. 135, 1872.

Body broad and flattened behind the clitellus, rounded and tapering in front of it. Upper lip large, dilated, wrinkled, and radiately sulcated beneath; œsophagus with three broad folds, as in *Nephelis*. Intestine simple, resembling that of *Trocheta*. Ocelli eight, in the typical species. External male organ expanded at the end into a disk-like form, with a raised margin and depressed center, in which there is a four-lobed orifice, as in *Trocheta*. The internal male organs resemble those of *Aulastomum* and *Hirudo;* the testicles being rather large, rounded or pyriform vesicles, apparently but eleven on each side.

This genus has a remarkable combination of the characters of *Nephelis*, *Trocheta*, and *Aulastomum*. In general habit and form of body, it is much like *Trocheta*, but there are no maxillæ.

NEPHELOPSIS OBSCURA Verrill.

American Journal of Science, vol. iii, p. 135, 1872.

Body much elongated in extension, depressed posteriorly, distinctly annulated, a little rugose anteriorly in contraction. Length, in extension, 4 to 5 inches; breadth, 0.25 to 0.35 of an inch. Head obtusely rounded in front. Ocelli eight: two pairs on the first ring near the front, the inner pair larger, well separated; two pairs on the sides of the buccal segment, small, distant, the upper pair a little below the level of the outer pair of anterior ones. Inner surface of the upper lip very rugose, the sulcations and folds diverging outwardly. Mouth large; folds of the œsophagus broad, prominent, the outer end pointed, triangular. Anal orifice large, with raised borders, situated on the dorsal surface a little in advance of the posterior sucker, which is large, rounded, the disk expanded, and considerably larger than the pedicel. Clitellus much thickened; male organ short, protruded as a low truncate cone, with disk-shaped end. When examined by transmitted light, a row of eleven rather large, translucent, pyriform spots may be seen midway between the dark intestine and the flattened margin, which appeared to correspond with the testicles. Color, above and below, dull dark brown, umber-brown, or fuscous, usually with numerous obscure, narrow, longitudinal stripes of lighter and darker brown.

Var. b, maculata.—Form and size nearly as described above. Color of preserved specimens greenish yellow or clay-color, with small, irregular spots of black scattered over the back; lower surface nearly plain clay-color. Ocelli, eight, but often not very distinct in preserved specimens. Three small, acute, triangular lobes above and alternating with the upper ends of the œsophagal folds. A specimen from Fire Hole Basin was much darker; the black blotches being larger and more or less confluent.

Var. *a*.—Madison, Wisconsin, very abundant in the lakes near the city—A. E. Verrill.

Var. *b*.—San Luis Valley, Colorado, common—Lieutenant Marshall, Wheeler's expedition, 1873; Snake River—Dr. Josiah Curtis; lake near Long's Peak, elevated 9,000 feet—Hayden's expedition; Cool Spring, Fire-Hole Basin—Smithsonian Institution.

This species was first taken in Wisconsin, in May, 1870, when numerous egg-capsules were also found attached to the stones along the shores. These were yellowish in color, broad-oval or elliptical, terminating in a point or mucro at each end, flat below, smooth and slightly convex above, with a thin margin. They were $5^{mm}.5$ to 8^{mm} long by $3^{mm}.5$ to 4^{mm} broad. Each one contained from five to ten eggs, or young leeches; some of the latter were already leaving the capsules; these were 5^{mm} or more in length, and even at this age, though pale in color, they had the characteristic form of the adult, and the eight ocelli were distinctly visible.

NEPHELIS LATERALIS Verrill.

Hirudo lateralis Say, Long's Second Expedition, vol. ii, p. 267, 1824; Diesing, Syst. Helm., vol. i, p. 474.

Nephelis lateralis Verrill, American Journal of Science, vol. ii, p. 451, 1871; vol. iii, p. 133, 1872.

? *Nephelis vermiformis* Nicholson, Canadian Journal, 1873, (young.)

The original specimens, described by Say from the waters between Rainy Lake and Lake Superior, were dull livid with "a few very remote minute black points, and a rufous line along each side;" the "six ocular points are placed in a regularly curved line."

Specimens from New Haven, apparently belonging to the same species, were 3 or 4 inches long in extension, and 0.15 to 0.25 of an inch wide; rather slender and subterete anteriorly, somewhat depressed posteriorly, with the margins rounded. Head obtusely rounded in front, not very distinctly annulated. Ocelli six, distinct, sometimes with faint colored spots, like indications of another pair on the first segment; the front pair, on the first segment, is very distinct and much larger than any of the others, well separated, round, and blackish; the two pairs on the sides of the buccal segment are very small and well separated. Acetabulum as wide as the body, when extended, with a circular row of blackish submarginal spots. The three folds of the œsophagus are about as in the following species. The color above is sometimes plain dark brown, and often dull dark orange-brown, with numerous fine longitudinal lines, alternately darker and ligher, and with many small irregular black spots scattered unevenly over the surface, except along the middle of the back; an obscure reddish line passes along each side near the margin, apparently due to an internal vessel showing through the integuments; lower surface plain, dull orange-brown, somewhat lighter than the back; head light flesh-color. Several other varieties occur. Some are nearly black, with few scattered lighter specks; others are pale brown, or light slate, specked with small darker brown or blackish spots.

Whitneyville Lake, and Farmington, Conn., and Peak's Island, Casco Bay, Maine—A. E. Verrill; Bad River and Madeline Island, Lake Superior—J. W. Milner; Clear Lake, Colorado, (plain brown variety)—Hayden's expedition; Lake Huron (pale variety)—J. W. Milner.

NEPHELIS QUADRISTRIATA Grube.

Famil. des Annel., pp. 110 and 149; Diesing, Sitzungsberichte der kaiserlichen Akad. der Wissenschaften, math.-naturwiss. Classe, xxxiii, p. 496, 1859; Verrill, op. cit., vol. iii, p. 133, 1872.

Body, in extension, 2 to 4 inches long, by 0.12 to 0.25 inch broad, slender subterete, tapering to the anterior end; in contraction broader and somewhat depressed posteriorly; the sides rounded. Posterior sucker large, nearly as wide as the body, to which it is broadly attached. Mouth rather large, suborbicular, the upper lip a little expanded, rounded in front, wrinkled within, smooth externally, and not distinctly annulated

The œsophagus has the three longitudinal folds slightly prominent, rounded at their exterior ends. Six ocelli were all that could be distinguished; of these, those of one pair, situated on the front of the first segment, are much the largest; two pairs, much smaller and inconspicuous, are placed well apart on the sides of the buccal segment. Anal orifice large, with a raised border, situated a little in advance of the posterior end of the back.

Color above, brownish black, dark brown, fuscous, or dark cinereous, with four longitudinal rows of irregular, nearly confluent, black spots, intermingled with light brown or grayish spots, which often also form the centers of the black spots. Lower surface plain brown or fuscous, usually a little lighter than the back.

Var. b.—Back with a light reddish or brownish median stripe, and a broad band of blackish on each side, often more or less interrupted with lighter mottlings.

Var. *a.*—New Haven and Farmington, Conn.—A. E. Verrill; Falmouth, Mass.—Dr. Edw. Palmer; Lake Raymond, Nebraska—T. M. Prudden, 1873. This variety is very common in the fresh waters of New England.

Var. *b.*—Yellowstone Lake—Dr. Josiah Curtis; San Luis Valley, Colorado—Lieutenant Marshall, Wheeler's expedition, (also var. *a*;) Colorado—Hayden's expedition 1873, (var. *b*, and plain dark brown variety.)

NEPHELIS MARMORATA Verrill.

American Journal of Science, vol. iii, p. 134, 1872.
Hirudo marmorata Say, op. cit., p. 267.
(?) *Nephelis punctata* Leidy, Proc. Acad. Nat. Sci. of Philad., 1870, p. 89.

This species, found by Say associated with *N. lateralis*, appears to differ in no important particulars, and may be only a differently colored variety of the same species. It is described as blackish or fuscous, with irregular whitish or light colored spots; beneath pale, generally immaculate, but sometimes with confluent black spots. Ocular points six, in a regularly curved line.

When a larger series of living specimens from various localities can be studied, the three preceding forms, admitted here as distinct, may prove to be mere varieties of one species, no less variable than the *Nephelis vulgaris* of Europe. The agreement in the number and arrangement of the ocelli is very close in the three forms.

The leech described by Dr. Leidy from the vicinity of Philadelphia and from Beverly, N. J., appears to differ in no essential characters. It was blackish olivaceous above; the annuli minutely punctate with yellowish olivaceous or dusky white, and narrowly bordered with the same; beneath grayish.

NEPHELIS FERVIDA Verrill.

American Journal of Science, vol. ii, p. 451, 1871, and vol. iii, p. 134, 1872.

Body 2 or 3 inches long, 0.20 to 0.30 of an inch wide, elongated and slen-

der in full extension, very little depressed, most so posteriorly, often round and tapering anteriorly. Mouth large, nearly circular, subterminal; the upper lip, in contraction, short and rounded; within the œsophagus are three conspicuous folds. Ocelli eight, small, nearly equal, blackish, conspicuous; two pairs, a little apart, on the first ring of the head; two pairs, wider apart and farther back, on the third ring. Color, bright brick-red when living; the preserved specimens show numerous faint longitudinal lines of brown.

In 8 to 13 fathoms, south side of Saint Ignace, Lake Superior—S. I. Smith.

A small specimen, probably the young of this species, taken in 13 to 15 fathoms, in Simmons' Harbor, was translucent, tinged with flesh-color, with a dark brown intestinal line posteriorly.

Egg-capsules, apparently of this species, were found in August by Mr. Smith, attached to the leaves of *Nupha*, in a small lake near Simmons Harbor. These are broad-oval or elliptical, above smooth and convex, translucent yellowish brown, with a thin, flat, lighter border, each end prolonged slightly into a short tubular neck, with a terminal orifice Lower surface flat. Each contained two, three, or more young leeches, mostly upward of half an inch long, plain whitish, with eight distinct black ocelli. The largest capsule was $11^{mm}.5$ long by 9^{mm} wide, including the margin; the smallest was $9^{mm}.5$ long by $7^{mm}.5$ wide. These capsules closely resemble those of *Nephelopsis obscura*, but are larger than those that were found to belong to that species.

This species approaches *Nephelopsis* in several characters, and especially in having eight distinct ocelli. When more specimens, and of larger size, can be examined, it may prove to be a true *Nephelopsis*.

CLEPSINE Savigny.

This genus is very abundantly represented in our waters, both in individuals and species. All of these species are apt to be quite variable in character in different localities, as well as at different periods of growth. Most of the species are elegantly, and some are quite brilliantly colored, but the colors are often quite variable in the species, and cannot be relied upon for distinguishing them without other characters of more importance. The form varies extremely, according to the state of contraction or extension. They are most frequently found adhering to the under surfaces of floating logs and old pieces of boards, or beneath the loosened bark of submerged branches and trunks of decaying trees. Occasionally, they adhere to the lower surface of larger leeches, turtles, or other animals, but they probably never suck blood. They feed upon insect larvæ, small worms, mollusks, &c. When disturbed, these species curl themselves up after the manner of "pill-bugs" and certain insect larvæ. The eggs, when laid, are retained in a cluster beneath the expanded and concave posterior portion of the body, which is arched over them and kept in continuous undulatory motion during

the period of incubation. The young, when hatched, adhere in a group to the posterior part of the lower surface of the body of the parent by means of their posterior suckers, and before quitting the parent usually present the essential characters, and often nearly the pattern of color of the adult, though paler.

Section A.—Ocelli 2, separate or confluent.

Subsection *a*.—Back smooth.

CLEPSINE PARASITICA Diesing.

Hirudo parasitica Say, Major Long's Second Expedition to the Source of Saint Peter's River, Lake Winnepeek, &c., vol. ii, p. 266, 1824.
Clepsine parasitica Diesing, Systema Helminthum, vol. i, p. 450, 1850; Verrill, op. cit., vol. iii, p. 128, 1872.

This species is one of the largest and most conspicuously colored of the genus.

Body smooth, but distinctly annulated, much depressed, broad, tapering anteriorly to the obtusely rounded head, broad and emarginate posteriorly, with a broad, round, posterior sucker or acetabulum, about half of which is exposed behind the end of the body. Length, in extension, 3 inches; greatest breadth 0.3 to 0.5 of an inch, according to the degree of extension. Ocelli usually united into one inconspicuous spot, placed near the anterior margin of the head; two or three other minute black spots, somewhat resembling ocelli, sometimes occur along the margins of the head anteriorly.

Upper surface variegated with green, yellow, and brown; the ground-color is usually dark greenish brown, with a broad median vitta of pale greenish yellow, which at intervals expands into several large irregular spots; unequal, oval, and rounded spots are also irregularly scattered over the back. The entire margin is surrounded by a series of alternating square spots of dark green and yellow. Lower surface longitudinally striped with numerous purplish brown and black lines; the margin spotted like that of the upper side.

West River, near New Haven, Connecticut, on the lower side of floating wood, and at Norway, Maine—A. E. Verrill; frequent in the lakes of the Northwestern States, adhering to the sternum of tortoises—Say

CLEPSINE PICTA Verrill.

Op. cit., vol. iii, p. 128, 1872.

Body smooth, much depressed, broad posteriorly, somewhat tapering anteriorly, about 2.50 inches long in extension, varying in greatest breadth from 0.25 to 0.30 of an inch. Acetabulum large, rounded. Ocelli two, close together, and sometimes confluent, surrounded by a triangular white area, which extends backward. Color of upper surface, dark brownish green, finely variegated with orange; toward the margins the green becomes brighter; a row of semicircular orange spots, centered with flesh-color or white, extends along each margin. Small, distant,

flake-white spots are scattered over the upper surface, and arranged in about five irregular longitudinal rows. Acetabulum varied with green and orange, the green forming rays toward the margin, alternating with salmon-colored spots. Lower surface darker than the upper; deep greenish on the central part.

Another variety agrees in most respects with the preceding, but has a median, brown line along the back, interrupted by six irregular light green blotches, the last one largest and elongated, the rest of the back purplish brown varied with greenish, the colors appearing as if in fine checks, owing to lighter and darker lines running in both directions; a row of rounded light green spots on each side midway between the dorsal line and margins, and a row of flesh-colored semicircular spots, alternately large and small, along the margin. Acetabulum varied with light purple and flesh-color. Lower surface pale bluish, with lighter lines.

A young specimen, about 0.75 of an inch long, had the same pattern of color, but the upper surface was lighter, reddish brown, and the dark brown lobes of the intestine were visible through the integuments.

Other variations of color were observed. In some, the blotches interrupting the median brown line were dull orange, and the marginal spots were orange-yellow. The sides of the back were orange-brown, thickly specked with dark brown and with a row of small pale green spots on each side; lower surface plain purplish brown, and there was a whitish spot in front of the ocelli.

Whitneyville Lake and West River, near New Haven; common on submerged or floating wood, and beneath dead bark, in stagnant pools near New Haven, April 20, 1873, without eggs or young—A. E. Verrill.

CLEPSINE MODESTA Verrill.

Op. cit., p. 129, fig. 2, 1872; vol. v, p. 388, 1873
Clepsine submodesta Nicholson, Canadian Journal, 1873.

Body in extension elongated, tapering and very slender anteriorly, broader and obtusely rounded posteriorly. Length, 0.5 of an inch in extension. Back smooth, faintly annulated, translucent. Head small, obtuse, whitish. Ocelli two, black, near together. The general color above is usually pale purplish brown or purplish flesh-color, with minute specks of brown and very small round spots of dull yellow, and often of light green; margins and a median dorsal line, pale. Acetabulum moderately large; whitish. Auditory vesicle or "cervical gland," placed near the head, small, rounded, slightly prominent, conspicuous, deep brown, surrounded by a whitish circle. Lower surface pale purplish. The attached young, about 0.3 of an inch long in extension, were slender, whitish, and subdiaphanous, with the brown intestine showing through posteriorly.

Fig. 1

West River and Whitneyville Lake, with the preceding, and carrying

young, common; very abundant in stagnant pools near New Haven, April 20, 1873, without eggs or young. White Mountains, Arizona—Lieut. Henshaw, Wheeler's expedition; Beaver Creek—Dr. H. C. Yarrow; Lake Raymond, Nebraska—T. M. Prudden, Yale scientific expedition, 1873; Lake Okechobee, Florida—E. Palmer; Springs, Saguache, Colorado—Ernest Ingersoll, Hayden's expedition.

Subsection *b*.—Back papillose.

CLEPSINE ORNATA Verrill.

American Journal of Science, vol. iii, p. 130, 1872.

The specimens of this species originally described, although found carrying young, were probably immature. Specimens of much larger size, and having more numerous papillæ, have since been obtained. They are so different as to be easily mistaken for another species, but their young have been found to agree with the original description. It is probable that this, and other species of *Clepsine*, begin to breed long before they become full grown, and that they live several years. The following is the original description:

"Body somewhat depressed, rather broad and obtusely rounded posteriorly, in extension tapering, but not slender anteriorly, about 1.25 inches long. In contraction elliptical, and about 0.20 broad in the middle. Back with a median papillose dorsal carina, and two similar ones midway between it and the margins. Head broad, acuminate, whitish in front and at the margins. Ocelli united into a single, small, transverse spot, situated at the edge of the white area. Acetabulum moderately large, round, about half of its breadth exposed behind the end of the body.

"A dark green line passes along the median carina, interrupted anteriorly by several transverse orange vittæ, and farther back by some pale orange spots; the first of the transverse spots or vittæ is pale orange, and is just behind the white area of the head; this is followed by a transverse greenish brown one, which is succeeded by a longer transverse orange one; farther back is another transverse vitta, or band, of the same color. The posterior part of the back and upper side of acetabulum are flesh-color, specked with pale orange and purplish. The papillæ of the lateral carinæ are partly orange and partly brown. The margin is pale purplish, with conspicuous squarish spots, alternately bright green and orange. The rest of the upper surface is variegated with bright green and pale brown, and specked with darker brown. Lower surface pale green, with a median light line; the margins colored as on the upper side.

"The attached young, June 6, were about 0.12 of an inch long, and very slender in extension. Anteriorly, they were purplish red, with bright red specks, and with a median row of red points, while several median white spots occupied the positions of the large transverse orange spots of the adults. Posteriorly the branched lobes of the intestine gave a

greenish color to the body. Ocelli closely united into a transversely triangular or bilobed spot of bright red.

"West River, on the lower sides of submerged wood and pieces of boards."

Var. b, stellata.—Body broad-oval in contraction; moderately elongated in extension; strongly annulated; in extension, about 1.25 to 1.50 inches long, and 0.20 to 0.30 broad; in contraction, about 0.40 long, but sometimes larger than this; head obtuse in front; ocelli more or less confluent into a conspicuous transversely triangular or bilobed eye, usually surrounded by a white area; back moderately convex, with numerous quite small papillæ, forming a transverse row on each annulus. Along the middle of the back, there is a longitudinal row of somewhat larger and more prominent, yet small, conical papillæ, and two similar rows exist on each side, between the median row and the margins. The larger papillæ are usually tipped with white; color above variegated dark greenish brown, with a median line and marginal spots. The surface is covered with brown and green stellate specks, and sometimes with some orange-colored ones, the green ones generally prevailing toward the margins. Along each edge and around the acetabulum, there is a series of flesh-colored, pale yellowish, or light orange semicircular spots; head with a transverse median spot of white. A pale yellow or white transverse line crosses the neck. The dark green, brown, or blackish median dorsal line is scarcely interrupted. One or two longitudinal rows of flake-white often extend along each side of the median line on the papillæ, and similar white specks are often scattered over the back; lower surface brownish, with stellate specks of green; near the margin, like the upper surface. Some of the specimens, which were quite dark colored when caught, in April and early in May, carried large clusters of bright, deep yellow eggs, and others were just laying. The specimens, though quite dark colored when taken, were kept until July 17. By that time they had become much lighter, the yellow, pale orange, and greenish hues prevailing, though stellate specks of dark green and brown were still present.

Var. c, rugosa.—Larger than the preceding; strongly annulated, each annulation with a row of 20 to 30, or more, larger, conspicuous, rough, conical papillæ, with many unequal smaller ones between them, in several irregular rows, or scattered. Ocelli very close together, but separated by a narrow light line, in adult preserved specimens; united in the attached young. The color, in alcoholic specimens, is yellowish green, variegated with blotches of dark brown; margin of body and acetabulum with semicircular, pale, orange spots, covering the width of about two annulations, and separated by narrower, greenish brown spots, about half as wide; head with a light, longitudinal vitta. The attached young have three dorsal, longitudinal rows of small papillæ, the median one double

posteriorly, and a few others scattered over the surface between. The most papillose specimens were collected by Dr. Elliott Coues, on the northwest-boundary commission. This may prove to be a distinct species, but this is rendered improbable on account of the close agreement of the attached young with the ordinary varieties.

Var. d.—The largest specimen that I have seen belonging apparently to this species was over 3 inches long in extension, and upward of half an inch wide. The body was strongly annulated, with crenulated margins; on each annulation there was a transverse row of numerous small but conspicuous papillæ. Ocelli united. The color was dark olive and fuscous brown on the back, with a row of small, semicircular, light yellowish spots along each margin at every third annulation; head with an interrupted pale yellow vitta; ventral surface striped with olive-green and dull grayish. This specimen was taken, without eggs or young, near New Haven, about the 1st of May.

Another somewhat similar specimen, from the same locality, was 3 inches long in extension, and 0.5 to 0.75 broad; in contraction, 1.5 long and 1 inch broad. Body much depressed, with thin margins, obtuse anteriorly. Back covered with numerous small, unequal, conical or rounded verrucæ, arranged in transverse rows of twenty or more on each annulation. Ocelli black, confluent, or very closely approximate. Head, in front of ocelli, brownish white, with lateral brown spots; behind the ocelli, with a short median orange-brown stripe. General color of body dark greenish brown. The ground-color is brown, varied with very numerous minute stellate specks of dark green; toward the lateral margins of the body and edges of the acetabulum, the color is lighter orange-brown, with fewer green specks; and a marginal series of roundish pale brown spots extends along each side and around the acetabulum; beneath, pale bluish, with sixteen to twenty stripes of green.

On the lower side, the dark brown viscera show very distinctly, through the integuments, eleven branches or lobes on each side; these are elongated, well separated, with few short open branches; the anterior ones are but little shorter and are not crowded. In this respect, this species is very distinct from *C. picta*, in which the branches are twenty or more on each side, short, much branched, crowded, the anterior ones becoming much smaller and more crowded.

Var. *a.*—West River and Whitneyville Lake, New Haven—A. E. Verrill.

Var. *b.*—Pools near Goffe street, New Haven, on submerged wood, and adhering to the ventral surface of *Macrobdella decora*—A. E. Verrill; Clear Lake, Colorado, Hayden's expedition; Snake River—Dr. J. Curtis, Wheeler's expedition; Birchwood Creek, Nebraska—O. Harger, Yale scientific expedition, 1873; No. 183—Dr. Yarrow, Wheeler's expedition.

Var. *c.*—Northwest-boundary survey—Dr. Elliott Coues.

Var. *d.*—Pools near Goffe street, New Haven—A. E. Verrill.

CLEPSINE PAPILLIFERA Verrill.

Op. cit., vol. iii, p. 130, 1872.

Body decidedly convex above, broad and obtusely rounded behind; in extension long, slender, and tapering anteriorly. Length, when extended, about 1 inch; greatest breadth, in contraction, about 0.20 of an inch. Back covered with small, distant, subconical papillæ, arranged in transverse rows, of which the anterior contain about three papillæ, and the posterior ones eight or nine. Head small, narrow, subacute, white in front. Ocelli two, distinct, but close together, black, placed at the posterior edge of the white area. Color above, obscure yellowish brown, produced by alternating narrow lines of flesh-color and olive-brown, which are crossed by fine longitudinal lines of dull olive-green, giving a checkered appearance under the microscope. The dorsal papillæ are specked with opaque white at the tips, and usually surrounded by a darker spot of olive-green at the base.

Var. b.—Specimens taken in Whitneyville Lake, October 4, carrying young, differ considerably from the preceding, and may prove distinct. These have the form of body, head, and ocelli as described, but the tubercles of the back are less numerous, forming a single median row anteriorly, which becomes double posteriorly, where there is also a row on each side, midway between it and the margin. The general color above is dull greenish yellow, transversely and longitudinally lined with lighter; the tubercles are dark brown, and small flesh-colored spots are scattered over the back, but form rows posteriorly. Lower surface lighter.

Var. c.—The specimens thus designated in my former paper appear to belong rather to *C. ornata.*

Var. d, lineata, nov.—Body in contraction broad-oval, much depressed. Ocelli two, distinctly separated by a space equal to about twice their diameter. The alcoholic specimen has about twelve longitudinal stripes of deep brown, alternating with as many of yellowish white; both crossed by fine transverse lines of whitish. Back nearly smooth, with only a few minute and but slightly raised papillæ. This may prove to be a distinct species.

Var. e, carinata, nov.—Body in contraction rather short and thick, tapering rapidly to the head. Ocelli two, conspicuous, well separated, with a space between equal to their diameter, or greater. Back with three conspicuous carinæ, each surmounted by a close row of prominent papillæ; toward the posterior end, the middle carina ceases, and a short one, with few papillæ, is introduced on each side of the median line close to the posterior end of the body; other much smaller papillæ are usually scattered over the surface between the principal rows, especially near the margin, where they often form a submarginal row. Color, of alcoholic specimens, dull brown; the back covered with many narrow longitudinal stripes of dark brown, alternating with lighter lines.

West River, Conn., and in small tributary streams, among the stems of

water-plants and on floating wood, common—A. E. Verrill; Bad River, Lake Superior—J. W. Milner (var. with few large papillæ, mostly in three rows.)

Var. *d.*—Lake Raymond, Nebraska—T. M. Prudden; Lake Okechobee, Florida—Dr. E. Palmer.

Var. *e.*—Ecorse, Michigan—J. W. Milner.

Section B.—Four ocelli.

No American species belonging to this section are known to me.

Section C.—Six ocelli.

Subsection *a.*—Back smooth.

CLEPSINE PALLIDA Verrill. (Fig. 2, *a*; head enlarged.)

Op. cit. vol. iii, p. 131, fig. 3, *a*, 1872.

Var. a.—Body depressed, broad and obtusely rounded posteriorly, tapering, but not very slender, anteriorly; about 1 inch long in extension, and 0.15 of an inch broad in contraction. Back smooth, somewhat convex. Head obtuse, with six ocelli, those of the anterior pair nearer together. Acetabulum rather small. Intestine whitish, showing through the integuments, with two large anterior lobes and about six smaller lateral ones. Auditory vesicle very distinct. Color above pale yellowish, with scattered blackish specks, and with a median light line, interrupted by a row of distant, small, black spots. Beneath pale flesh-color.

b Fig. 2. *a*

Var. b.—Back smooth, grayish green, with two dorsal dark lines, and specked over the whole surface with small blackish dots, which are arranged somewhat in longitudinal lines. Ocelli as in var. *a*. Length about 0.75 of an inch, (18mm to 20mm.) Taken September 17.

West River, New Haven, Conn., both varieties, on submerged wood—A. E. Verrill; Colorado—Hayden's expedition; lake near Long's Peak, elevated 9,000 feet—Hayden's expedition, 1873; (var. *b*, with narrow, dark stripes.)

Subsection *b.*—Back papillose.

CLEPSINE ELEGANS Verrill. (Fig. 2, *b*; head. See above.)

American Journal of Science, vol. iii, p. 132, fig. 3 *b*, Feb., 1872; vol. v, p. 387, 1873.

Clepsine patelliformis Nicholson, Canadian Journal, 1873.

Body depressed, strongly annulated, broadly rounded posteriorly, tapering, but not slender, anteriorly. Length, in extension, about 1.25 inches; breadth, in contraction, 0.20 of an inch. Acetabulum moderately large, projecting considerably beyond the posterior end of the body. Head small, obtusely pointed, white in front and along the edges. Ocelli six, the three pairs close together on the white area of the head, those of the middle pair largest, black. Back covered with distant, slightly elevated, yellow papillæ. Color olive-green, thickly specked, especially toward the margins, with purplish brown, and with dark brown transverse lines, corresponding with the intervals between the annulations;

anteriorly there is a pale yellowish green median line; a slight distance from the middle there is, on each side, a narrow black line extending the whole length, and between these and the margins there are other faint longitudinal lines. Along each margin, there is a row of about six sulphur yellow spots, and a few smaller raised yellow spots are scattered over the back, the anterior ones often becoming greenish. Lower surface pale green, specked with brown, and with a light median and two black longitudinal lines, corresponding to those above.

Var. b.—Two anterior ocelli nearer together than the others. Body deep brown, in preserved specimens, with six or more irregular rows of yellow spots on slightly raised papillæ.

West River, with the two preceding—A. E. Verrill; Lake Ontario—Nicholson; northwest-boundary survey—Dr. E. Coues, (var. *a* and *b*.)

This is a very active species. It adheres firmly by means of its posterior sucker, but when much disturbed quickly rolls itself into a ball. One of the specimens, taken June 6, carried about a dozen slender young ones, of a pale pink-color.

In addition to the preceding species, *Clepsine oniscus* Diesing, (Blainville, sp.,) and *Clepsine swampina* Dies. (Bosc, sp.,) have been indicated from North America. The first has not been described sufficiently to be recognized, all the characters mentioned applying equally to nearly every species of the genus.

Clepsine swampina Diesing is thus described: "Body subelliptical, depressed, anteriorly narrowed, above transversly sulcated, below plumbeous. Ocelli six, two closely approximate. Acetabulum orbicular. Length, 6–7 lines; width, 3 lines."

Carolina, upon the surface of tortoises and frogs—Bosc.

Section D.—Ocelli 8.

Subsection *a*.—Back smooth.

CLEPSINE OCCIDENTALIS Verrill, *sp. nov.*

Body rather stout; in contraction thick and convex; about 0.75 of an inch long, and 0.30 broad; tapering to both ends. Ocelli eight: those of the second and third pairs largest; those of the third farthest apart; those of the fourth small and near together. Dorsal surface smooth, with faint indications of small, low papillæ anteriorly. Acetabulum small. Color, in alcohol, yellowish brown, with fine transverse lines of darker.

San Luis Valley, Colorado—H. W. Henshaw, Wheeler's expedition, 1873.

CYSTOBRANCHUS VIVIDUS Verrill.

Op. cit., vol. iii, p. 126, fig. 1, 1872.

Body elongated, somewhat depressed, tapering both ways, but most so anteriorly. Surface smoothish, but with minute, hemispherical hya-

line vesicles. Length, in extension, about one inch; breadth, in middle, 0.10 to 0.12 of an inch. Head excentrically pedicellate upon a slender neck, small, disk-like, rounded in front, or somewhat heart-shaped, with the rounded point forward. Ocelli four, small, brownish, placed near the attachment of the neck on each side; those in the anterior pair farther apart. Acetabulum large, well-rounded, as wide as the body, disk-shaped, and attached nearly centrally. Male organ, when protruded, elongated, conical, acute, placed just behind the fourth pair of large lateral white spots.

Color of back dusky brown or purplish brown, finely specked with stellate points of darker brown, and with three irregular rows of conspicuous, small, round, opaque white spots along the upper surface of the back. Sides with a row of about 16, larger and more conspicuous, semicircular, white spots along the margin, each consisting of a cluster of 3 to 9 small round spots, inclosing a more transparent area, in which a diaphanous pulsating vesicle or enlarged vessel may be seen to protrude at each pulsation. Lower surface of body light grayish, specked with darker, and often with obscure transverse bands of whitish; acetabulum similar in color to the body, with small, round, white spots, the margin more or less radiated with lighter and darker. Upper surface of head similar to the back; the sides and front lighter.

West River, near New Haven, on *Fundulus pisculentus*, November and December, 1871—F. S. Smith; Savin Rock, in salt-water, among eel-grass—Prof. J. E. Todd; Casco Bay, among eel-grass, 1873—A. E. Verrill.

This very active species lives in both fresh and salt water.

The transparent lateral vesicles referred to are probably organs of respiration, analogous to the much more highly developed branchial appendages of *Branchiobdella*.

ICHTHYOBDELLA FUNDULI Verrill.

Op. cit., vol. iii, p. 126, 1872.

Body smooth, distinctly annulated, subterete, thickest at about the posterior third, tapering considerably toward the head, and slightly posteriorly. Length about 0.75 of an inch; greatest diameter about 0.08. Head small, rounded in front, scarcely explanate, and separated only by a slight constriction from the body. Ocelli four: two larger well separated, placed near the posterior part of the head; two others, very small and scarcely distinguishable in some specimens, are placed in front of these. Acetabulum scarcely wider than the body, obliquely attached, sessile, and scarcely separated by a constriction from the body. Color light green, finely specked with dark green and brown points; sometimes with distinct bands of whitish alternating with the green on the anterior part of the body, and with a pale dorsal line; neck with a pale band at the constriction.

West River, Conn., on *Fundulus pisculentus*, November and December,

1871, and December 18, 1872—F. S. Smith; near New Haven, on the same fish—Prof. J. E. Todd.

This species differs greatly, in the form and arrangement of the acetabulum and head, from the typical species of the genus, and, when living specimens can be carefully studied, may require separation.

ICHTHYOBDELLA PUNCTATA Verrill.

American Journal of Science, vol. ii, p. 451, 1871; vol. iii, p. 127, 1872.

Body, in extension, slender, in the preserved specimen, about 0.5 of an inch long, 0.06 in greatest diameter, rounded, thickest posteriorly, tapering anteriorly to the anterior sucker, which is broad and thin, subcircular, about three times as wide as the neck where it is attached. Ocelli four, on the upper side of the anterior sucker: two larger, black ones, in front; and two minute ones wider apart and farther back. Posterior sucker large, rounded or oval. Color translucent greenish, with a pale median dorsal line, and with minute black specks arranged in transverse bands; along each side are eight light spots, alternating with the dark punctate bands.

Among the Slate Islands, Lake Superior, in 6 to 8 fathoms—S. I Smith.

ICHTHYOBDELLA MILNERI Verrill, *sp. nov.*

Body slender, elongated, a little depressed, in alcoholic specimens about 0.75 of an inch long, and 0.06 to 0.08 broad. Ocelli four, conspicuous, the anterior pair larger and wider apart; the head is quite oblique, broadly expanded, and extends out in front far beyond the ocelli. Acetabulum large, about twice the diameter of the body, with a circle of about twelve black, ocelli-like spots, around the middle. Color of body, in preserved specimens, yellowish, with four longitudinal rows of connected large angular spots of greenish, of which one extends along the upper, and one along the lower side, near the margins, leaving a pale band along the middle of the back and of the ventral surface; that of the back is often interrupted by the encroachment of the lateral green spots, the points of which frequently meet across the back, dividing the median pale band into a series of large rounded or transversely elliptical spots. The lateral green spots are variable in form, but often rhomboidal, with the most acute angle toward the median line of the back; they are connected along the margins by a nearly continuous band of green, or else by two narrow lines of green, separated by a pale line. The green spots are made up of small stellate specks of deep green, intermingled with others of orange. Head and acetabulum pale, but usually more or less specked with green and orange; the acetabulum often has a marginal circle of pale spots, alternating with greenish.

Thunder Bay, Michigan, in 25 fathoms, abundant, and also in floating weeds—J. W. Milner, 1873.

ASTACOBDELLA PHILADELPHICA Leidy.

Proceeedings of the Academy of Natural Sciences of Philadelphia, vol. v, p. 209, 1851.

Dr. Leidy's description is as follows: "Body whitish, translucent; sides nearly parallel, a little broader posteriorly, 16 alternately broad and narrow segments, exclusive of head and posterior end. Head campanulate, terminated by a circular or elliptical crenated lip, fringed with very minute stiff hairs, one two-thousandth of an inch long."

"Acetabulum circular, one-sixth to one-fourth of a line in diameter; mouth elliptical. Dental plates brown, nearly equal, forming an isosceles. triangle, with the base longest and attached. Apex of superior plate ending in a sharp conical point; with several very minute denticulations on each side. Apex of inferior plate bifurcated into two points, with two minute denticulations on each side. Stomach capacious, nearly filling the anterior eight alternately broad and narrow segments posterior to the head. Anus dorsal, one-fifth of a line from the acetabulum. Generative aperture ventral, anterior to the anal aperture.

"Length, one to four lines; breadth, one-sixth to one-half of a line. Head, one-sixth to one-half of a line long. Ovum attached by a pedicle, with an operculum pointed at summit. From base of attachment to point of opercle, one-fifth of a line. Length of body of ovum, one-sixth of a line; breadth, one-eighth of a line.

"*Habitat.*—Found frequently in numbers from one to several dozen upon any part of the exterior of the body of *Astacus Bartonii* Fab., but more especially upon the inferior surface and the branchiæ."

The following species, which I have not seen, have been described from North America:

LIOSTOMUM COCCINEUM Wagler.

Isis, 1831, p. 533; ibid., 1832, p. 53; Diesing, Sitzungsb. der kais. Akad. der Wissenschaften, xxxiii, p. 495, 1859.

This genus is remarkable in having no ocelli, and no folds, lobes, nor plications within the mouth and œsophagus.

Mexico—Karwinsky.

HIRUDO ORNATA Ebrard.

Nouv. Monog. Sangs., p. 55.

Northwestern America.

HIRUDO(?) COSTARICENSIS Grube and Œrsted.

Diesing, op. cit., p. 509.

Costarica—Œrsted.

HIRUDO BILLBERGHI Kinberg.

Op. cit., p. 356, 1867.

This species is described as having eight ocelli, with the genital orifice in the twenty-eighth segment. It probably belongs to some other genus.

OXYPTYCHUS STRIATUS Grube.

Fam. d'Annel., pp. 110, 148; Diesing, op. cit., p. 510.

Montevideo—Burmeister.

CENTROPYGUS JOCENSIS Grube and Œrsted, 1857.

Dies., op. cit., p. 511.

San José, Central America—Œrsted.

S Mis. 71——44

XXVII.—SKETCH OF THE INVERTEBRATE FAUNA OF LAKE SUPERIOR.

By Sidney I. Smith.

In the following paper, I have attempted to bring together all the species of invertebrate animals, excepting many aquatic insects and some groups of minute forms, known to inhabit the waters of Lake Superior. I had at first intended to make it a sketch of the invertebrate fauna of the entire chain of the great lakes, but found it impossible to bring together material enough for that purpose, and so have limited myself to the immediate region of Lake Superior. One of the principal objects of the article is to furnish a means of comparing the food of the fishes with the fauna of the waters which they inhabit. For this purpose, the fauna of Lake Superior is of more importance than that of the other lakes, since most of the material which I have examined from the stomachs of the lake-fishes was obtained in that lake by Mr. J. W. Milner. This account is undoubtedly very imperfect in all the groups; and some species which have been recorded as inhabiting the lake are very likely omitted, although I have intended to include all such. Of the insects I have attempted to mention only a very few species which are important as food for the white-fish, or interesting on account of the bathymetrical distribution. Most of the copepod and ostracoid *Crustacea* of the region are omitted, since they have not as yet been sufficiently studied by any one.

The account of the fauna of the depths of the lake is based almost entirely on a series of dredgings made during August and the early part of September, 1871, under the direction of General C. B. Comstock, superintendent of the survey of the northern and northwestern lakes and rivers. A preliminary report of these dredgings was made to General Comstock in October, 1871, and published as Appendix K in the Report of the Chief of Engineers, forming the second volume of the Report of the Secretary of War for 1871. Comparatively few of the shore-species were collected on this excursion, and consequently some parts of this paper have been largely compiled from other sources, especially from Professor Agassiz's work on Lake Superior. In all cases where the facts were not obtained by myself, however, I have given the authority on which they are inserted.

In order that the references to localities and depths may be better understood, I give a short account of the dredgings conducted by the lake-survey. The dredgings were all made by hand from the steamer Search, while employed in off-shore sounding, or in transporting shore-parties. The dredges used were like those commonly employed in marine dredg-

ing, with the addition of an inner bag of embroidery canvas, which was found necessary to retain the exceedingly fine clayey mud encountered at nearly every haul.

The following list will show the localities at which dredgings were made, the depth, and the composition of the bottom:

Simmons' Harbor, on the north shore of the lake, about twelve and a half miles north-northwest of Otter Island, August 9, 13 to 15 fathoms, bottom of fine sand, with scattered tufts of a small alga of the genus *Cladophora.*

Five miles off Simmons' Harbor, August 11, 60 fathoms, soft bluish clay.

Among the Slate Islands, August 14, while at anchor, two hauls: first, 12 to 14 fathoms, sand, with a little fine mud; second, from the other end of the steamer, 6 to 8 fathoms, sand, gravel, and small stones, with some mud.

On a line from the Slate Islands toward Stannard Rock, August 15, four hauls were made as follows: First, about eighteen miles south of the western end of the islands, 105 fathoms, soft clay; second, about thirty-five miles from the islands, 169 fathoms, the deepest point yet found in the lake, very soft light-drab clay, with small pieces of rotten wood; third, about forty miles from the islands, 116 fathoms, bottom same as in the last haul; fourth, about fifty-seven miles from the islands, 159 fathoms, very soft clay.

On a line southeast from Passage Island, off the east end of Ile Royale, August 18, hauls were made at five points: First, about six miles out, 47 fathoms, soft, reddish-clay and sand; second, about fifteen miles from Passage Island, 129 fathoms, soft clay; third, about twenty-nine miles from the island, 127 fathoms, bottom same as last haul; fourth, about forty-three miles from the island, 134 fathoms, bottom as in the last two hauls; fifth, about fourteen miles north of Keweenaw Point, 82 fathoms, two hauls, reddish clayey mud and sand.

North of Copper Harbor, August 22, dredgings were made at three different points: First, seventeen miles off, 148 fathoms, soft clay; second, nearer the shore, 62 fathoms, soft, reddish mud and sand; third, within a quarter of a mile of the shore, 17 fathoms, sand.

Off fifty miles, on a course northeast by east one-half north of Copper Harbor, August 24, 116 fathoms, soft clay.

In Neepigon Bay, due north of Saint Ignace station and half a mile from the shore of Saint Ignace Island, August 28, 32 fathoms, very soft clayey mud.

In the cove at the eastern end of Saint Ignace Island, near Saint Ignace station, August 29, 4 to 6 fathoms, sand, with some mud, bits of wood, &c.

About three miles south of the same cove, August 29, 73 fathoms, soft clayey mud.

In a small harbor on the south side of Saint Ignace Island, between

the main island and a smaller one, and due south of Saint Ignace station, September 4, two hauls, 8 and 10 to 13 fathoms, a little sand and mud brought up with great quantities of the same species of alga found at Simmon's Harbor, and which, according to Prof. D. C. Eaton, who kindly examined it for me, is a small, densely-tufted species of *Cladophora*, possibly *C. glomerata* Linn., a most variable species, but the specimens do not well correspond with authentic ones from Germany. This alga was brought up in immense quantities, the dredge being full at each haul.

On a line between Michipicoton Island and Copper Harbor, and about thirty-seven miles from the island, September 7, 147 fathoms, soft clay.

From this list it is readily seen that, in all the deeper parts of the lake, the bottom is covered with a uniform deposit of clay or clayey mud. All the soundings made by the lake-survey show the same thing, the specimens of the bottom brought up from deep water by the lead being everywhere of the same character, varying only in color and somewhat in the amount of sand mixed with the clay. The color was not uniform even in the same dredgeful; drab and bluish masses of the clay being frequently mixed with brown or reddish lumps. In deep water, drab and bluish were the prevailing tints, however. Water was taken from the bottom at many points, and was everywhere perfectly fresh. That from 169 fathoms gave no precipitate with nitrate of silver.

The temperature, everywhere below 30 or 40 fathoms, was very uniform, varying only slightly from 39°, while at surface, during the season at which the dredging was carried on, it varied from 50° to 55°.

The fauna of the lake-bottom corresponds with these physical conditions. In the shallow waters along the shores, the fauna varies with the varying character of the bottom, while below 30 to 40 fathoms, where the deep-water fauna properly begins, the same species seem to be everywhere nearly uniformly distributed down to the deepest points. The soft clayey bottom is, however, very unfavorable to most forms of animal life, and, as we might expect, the fauna of this region is very meager. Except among the worms, it seems to have scarcely any species peculiar to it, and is characterized rather by the absence of many of the shallow-water species than by forms peculiar to itself.

Besides the dredgings made by the lake-survey, Mr. J. W. Milner dredged, in 1872, in 60 fathoms off Outer Island, and obtained several of the species which had been found the year before.

It is proper that I should make a special acknowledgment to Professor Verrill for the assistance he has given me in the preparation of this paper. The account of the worms in the preliminary report referred to was prepared wholly by him, and in the following pages the enumeration and description of the species of that class, with which I am unacquainted, has been made up wholly from his published papers and manuscript notes. Special acknowledgments to Messrs. Temple Prime and Charles M. Wheatley for assistance in determining some of the species of *Mollusca* will be found under that group.

ARTICULATA.

INSECTS.

DIPTERA.

Many different species of two-winged flies in the larva stage inhabit the waters of Lake Superior. The great majority of the species, however, inhabit only the shallower waters, and are never found below the depth of a few feet; and such species are very much more abundant in pools, marshes, &c., in the vicinity, than in the pure and cold waters of the lake itself, where, it seemed to me, there were much fewer of all kinds of insect larvæ than in the lower lakes. The slender worm-like larvæ of the numerous species of *Chironomus* were not uncommon in dredgings even from great depths, and some of the species apparently live in abundance over the entire bottom of the lake. The species of the genus seem to be very generally diffused; the larvæ of some of the species even inhabiting salt-water. The winged insects themselves are delicate, mosquito-like flies, with plumose antennæ, and often swarm in vast numbers about ponds and marshy ground. I mention a few of the different forms of these larvæ found in the lake. These forms of larvæ may each, very likely, represent several species in the adult state, but for the present purpose it is convenient to speak of forms which can be distinguished while larvæ.

CHIRONOMUS, species, *a*. (Plate III, figs. 20, 21.)

A large opaque-white larva and its pupa were common in all the shallower dredgings and down to 32 fathoms. Larvæ and pupæ of apparently the same form were found in the stomachs of white-fish taken at Sand Island and at Sault Sainte Marie.

CHIRONOMUS, species, *b*.

A semi-translucent larva, much more slender than the last, was found in many of the shallow dredgings, and was often common, even down to 147 fathoms. The same form was found in abundance in the stomachs of white-fish taken at Outer Island.

CHIRONOMUS, species, *c*. (Plate III, fig. 22.)

A small entirely blood-red larva occurred in 6 to 8 fathoms among the Slate Islands, and in 8 to 13 fathoms among *Cladophora*, &c., on the south side of Saint Ignace Island.

NEUROPTERA.

Many species of *Neuroptera*, especially of *Ephemeridæ* and *Phryganeidæ*, are found about the lake, but, as in the case of the *Diptera*, most

of the species are confined to the shallow pools and other small bodies of water about the lake, and do not occur, or only very sparingly, in the lake itself.

EPHEMERIDÆ, species.

The larva of one species was dredged in 32 fathoms in Neepigon Bay.

The species of this family did not seem to be abundant in the lake itself, and the cast skins of the pupæ were nowhere, as far as my observations went, in such great abundance as they are on the lower lakes.

HYDROPSYCHE, species.

The larva of a species, belonging apparently to this genus, was dredged in 13 to 15 fathoms at Simmons' Harbor. The larvæ, pupæ, and sub-imago of the same or a closely-allied species were found in great abundance in stomachs of white-fish taken at Sault Sainte Marie.

PHRYGANEIDÆ, species. (Plate III, figs. 18, 19.)

The larvæ of another Phryganeid, inhabiting a cylindrical, tapering tube, composed of bits of the stem of the *Cladophora*, among which it lives, were abundant in 8 to 13 fathoms on the south side of Saint Ignace Island, and in 15 to 18 fathoms at Simmons' Harbor. The larvæ and pupæ of the same or an allied genus were found in the stomachs of white-fish taken at Sault Sainte Marie.

ACARINA.

HYDRACHNA, species.

A small, dark-colored species was dredged in 4 to 6 fathoms in the cove at the eastern end of Saint Ignace Island. A species, apparently the same, occurred in the stomachs of the white-fish taken at Ecorse, Mich.

CRUSTACEA.

PODOPHTHALMIA.

CAMBARUS VIRILIS Hagen. (p. 638.)
CAMBARUS PROPINQUUS Girard. (p. 638.)
CAMBARUS RUSTICUS Girard. (p. 639.)
CAMBARUS BARTONII Erickson. (p. 639.)
MYSIS RELICTA Lovén. (p. 642.)

TETRADECAPODA.

AMPHIPODA.

HYALELLA DENTATA Smith. (p. 645.)
PONTOPOREIA HOYI Smith. (p. 647.)
GAMMARUS LIMNÆUS Smith. (p. 651.)
CRANGONYX GRACILIS Smith. (p. 654.)

ISOPODA.

ASELLOPSIS TENAX Harger, (p. 659.)

ENTOMOSTRACA.

CLADOCERA.

DAPHNIA GALEATA G. O. Sars. (Plate II, fig. 11.)

Om en i Sommeren 1862, foretagen zoologisk Reise i Christianias og Trondhjems Stiftor, p. 21, 1863, (*teste* Müller ;) E. P. Müller, Denmarks Cladocera, Naturhistorisk Tidsskrift, III, vol. v, p. 117, pl. 1, fig. 6, 1868.

A species of *Daphnia*, which I cannot discover to differ in the least from Müller's description and beautiful figures above referred to, was taken quite abundantly near the surface of the water a few miles south of Saint Ignace Island August 29, 1871, and was found in the dredge from 72 fathoms at the same locality. It was also found in the deeper dredgings in many parts of the lake, but was very likely taken each time near the surface in the dredge on its way up. A few specimens occurred in the stomachs of the white-fish taken at Outer Island and at Sault Sainte Marie.

This and the next species are transparent, and seem to be free-swimming animals, inhabiting the waters of the lakes away from the weedy shores or bottom, where most of the other species of the genus are found. In Europe, this species is found in the lakes of Scandinavia and Denmark, where it appears to have precisely the same habits as in Lake Superior.

It is possible that a minute comparison of specimens from Europe and America may reveal some differences similar to those which I have noticed in the species of *Pontoporeia* from the two countries, but with the figures and description referred to I can find absolutely no differences. The American specimens exhibit the same varieties of form in the head and teste as are described by Müller in European specimens

DAPHNIA PELLUCIDA Müller.

Op. cit., p. 116, pl. 1, fig. 5.

The remarks in regard to the identity of the last species apply equally to this. This species differs from the last in having the rostrum somewhat acute and curved backward instead of truncate, and in having the caudal stylets armed near the base with a series of slender teeth or spines and the rest of the way with very slender setæ, while in *D. galeata* they are without teeth or spines, and are furnished with setæ through their whole length. The front of the head is also more evenly rounded and less crested than it ever is in *D. galeata*, although that species varies much in this respect.

This species was taken at the same times and places as the last, and was also found among the contents of white-fish stomachs from Outer Island.

DAPHNIA PULEX (?).

Baird, Nat. Hist. British Entomostraca, p. 89, pl. 6, figs. 1–3, 1850 ; Lilljeborg, Cladocera, Ostracoda et Copepoda in Scania, p. 30, pl. 2, figs. 2, 3, pl. 16, figs. 10–12, 1853; Leydig, Naturgeschichte der Daphniden, p. 117, pl. 1, figs. 1–7, 1860; Müller, op. cit., p. 110, pl. 1, fig. 4.

A species which it is not easy to distinguish, by the figures and descriptions referred to, from the common *Daphnia* of Europe was found in great abundance in a small pond at Sault Sainte Marie by Mr. J. W. Milner. A more careful examination than I have been able as yet to make may, however, show it to be a distinct but very closely allied species.

BOSMINA, species undetermined.

Taken at the surface a few miles south of Saint Ignace Island.

EURYCERCUS LAMELLATUS Baird(?).

Op. cit., p. 124, pl. 15, fig. 1.

Lynceus lamellatus Lilljeborg, op. cit., p. 71, pl. 5. figs. 7–12; pl. 6, figs. 1–7; pl. 7, fig. 1, 1853; Leydig, op. cit., p. 209, pl. 7, figs. 52–56, pl. 10, fig. 72.

A species of *Eurycercus*, identical with or closely allied to the typical species of Europe, was dredged, among *Cladophora*, in 8 to 13 fathoms, on the south side of Saint Ignace Island, and is, doubtless, common in other similar situations.

LEPTODORA HYALINA Lilljeborg.

Öfversigt af Vetenskaps Akademiens Förhandlingar, 1860, p. 265, pl. 7, figs. 1–22; Müller, op. cit., p. 226, pl. 6, figs. 14–21; G. O. Sars, Om en dimorph Undvikling samt Generationsvexel hos Leptodora, Forhandlinger i Vidensk. Selsk. i Christiania, for 1873, pl. 1; Weismann, Ueber Bau und Lebenserscheinungen von Leptodora hyalina, Zeitschrift für wissenschaftl. Zoologie, vol. xxiv, p. 349, pls. 33–38, 1874.

A single somewhat mutilated specimen, which agrees well with the descriptions and figures above referred to, came up in the dredge a few miles south of Saint Ignace Island, in company with *Daphnia galeata*, *D. pellucida*, &c., and, like them, was undoubtedly taken in the dredge on its way up. It is one of the largest and most remarkable forms of *Cladocera* known. It is wholly transparent, and grows to fully half an inch in length. The shell is very small, and incloses no part of the body; the head with the large eye at its extremity is produced far forward; the basal portion of the natatory appendages is long and very stout, while the rami are comparatively short and four-jointed; the six pairs of legs are crowded together below the natatory appendages; and the abdomen is very long, and the last segment terminates in two stout stylets.

OSTRACODA.

Quite a number of species belonging to several different genera were dredged at different points in the lake, one or two species occurring

even down to 159 fathoms. They were more abundant, however, in shallow water, and were especially numerous in 8 to 13 fathoms, among *Cladophora*, on the south side of Saint Ignace Island.

COPEPODA.

Several species of *Copepoda* were often very abundant at the surface of the water, while I was on the lake, and large numbers were collected. Species were also brought up in the dredge at almost every haul, most of them the same species as those obtained near the surface, but some were different and undoubtedly from near the bottom. They were almost always abundant in the dredgings in which *Mysis* occurred, apparently furnishing most of its food.

SIPHONOSTOMA.

LERNÆOPODA SISCOWET Smith. (p. 664.)

LERNÆOPODA (?) COREGONI Smith. (p. 664.)

WORMS.

OLIGOCHÆTA.

LUMBRICUS LACUSTRIS Verrill.

American Journal of Science, 3d series, vol. ii, p. 449, 1871; and Preliminary Report on Dredging in Lake Superior, p. 1023, 1871.

About 42^{mm} long, 1^{mm} in diameter. Body round, distinctly annulated. Head short, conical, obtusely pointed. Setæ spine-like, strongly curved, acute, arranged two by two, those of each pair close together. Color reddish brown.

Abundant, in 8 to 13 fathoms, among *Cladophora*, on the south side of Saint Ignace Island; also from the stomachs of white-fish taken at Outer Island.

SÆNURIS ABYSSICOLA Verrill.

American Journal of Science, 3d series, vol. ii, p. 449, 1871; and Preliminary Report on Dredging in lake Superior, p. 1024, 1871.

Worm slender, attenuated posteriorly, about 7^{mm}.5 long, 0^{mm}.75 in diameter anteriorly. Body composed of about twenty-eight segments; those of the posterior half elongated; those of the anterior half shorter, separated by slight constrictions. Cephalic lobe short, subconical, rounded in front. Mouth large, semicircular. Intestine slender, moniliform, containing sand. Anus terminal, with three or four slight lobes. Setæ in four fan-shaped fascicles on each segment, commencing at the second segment behind the mouth. The two ventral fascicles are separated by a space equal to about twice the length of the setæ, of which there are five or six in each fascicle; the setæ are simple, acute, slightly curved, equal to about one-sixth the diameter of the body. The lateral

fascicles contain three to five somewhat shorter and straighter simple setæ. One specimen appeared to have four minute ocelli upon the upper side of the head.

Dredged off Copper Harbor, 17 fathoms, sand; off Simmons' Harbor, 60 fathoms; and on the line from the Slate Islands toward Stannard Rock, fourth haul, 159 fathoms.

SÆNURIS LIMICOLA Verrill.

American Journal of Science, 3d series, vol. ii, p. 450, 1871; and Preliminary Report on Dredging in Lake Superior, p. 1024, 1871.

Worm more slender than the preceding, attenuated posteriorly, composed of about 44 segments. Length about 8^{mm}, diameter $0^{mm}.4$. Cephalic lobe blunt, conical. Setæ in four fascicles upon each segment, six to eight in each fascicle anteriorly, four or five posteriorly. The setæ in all the fascicles are relatively long, slender, curved, and acute. Two tortuous red blood-vessels pass along the intestine, forming a loop at each segment. Intestine moniliform.

Dredged on the line between the Slate Islands and Stannard Rock, fourth haul, 159 fathoms.

CHIRODRILLUS Verrill.

Allied to *Sænuris*, but with six fan-shaped fascicles of setæ upon each segment, two of which are ventral, two lateral, and two subdorsal; setæ in the ventral and lateral fascicles four to nine, simple, acute, slender, curved like an italic *f;* those of the dorsal fascicles stouter and less curved, three to six in each fascicle. Intestine wide, somewhat moniliform. Anus terminal, large.

CHIRODRILLUS LARVIFORMIS Verrill.

American Journal of Science, 3d series, vol. ii, p. 450, 1871; and Preliminary Report on Dredging in Lake Superior, p. 1024, 1871.

Body rather short and not very slender, cylindrical, obtuse at both ends, distinctly annulated, composed of about 38 rings. Length about $7^{mm}.5$; diameter, $1^{mm}.25$. Cephalic lobe short, conical, obtuse; mouth large, semicircular beneath. Ventral fascicles of setæ near together, with about five setæ, which are rather short, simple, acute, little curved; lateral fascicles with five or six setæ of similar form and size; subdorsal ones similar. When preserved in alcohol, the body is usually curved ventrally, or in a simple coil. Color, when living, translucent whitish; intestine slightly greenish. A thickened smooth zone commences behind the tenth setigerous ring, occupying the space of about four segments.

Off Copper Harbor, 17 fathoms, sand; off Simmons' Harbor, 59 fathoms, clayey mud.

CHIRODRILLUS ABYSSORUM Verrill.

American Journal of Science, 3d series, vol. ii, p. 450, 1871; and Preliminary Report on Dredging in Lake Superior, p. 1024, 1871.

Subcylindrical, thicker anteriorly, distinctly annulated, composed of about 42 segments. Length, 6^{mm}; diameter, about $0^{mm}.5$. Cephalic lobe short, conical, obtuse; mouth large, semicircular. Ventral fascicles with eight or nine setæ anteriorly; five or six posteriorly. The setæ are long, slender, acute, strongly curved; those on the inferior side of the fascicles nearly twice as long as those of the upper side; setæ of the lateral fascicles five or six, slender, nearly as long as those of the ventral ones, and similar in form; dorsal fascicles with four or five shorter, stouter, and straighter, acute setæ.

Six miles southeast of Passage Island, 47 fathoms; on line from the Slate Islands toward Stannard Rock, fourth haul, 159 fathoms.

TUBIFEX PROFUNDICOLA Verrill.

American Journal of Science, 3d series, vol. ii, p. 450, 1871; and Preliminary Report on Dredging in Lake Superior, p. 1024, 1871.

A rather stout species for the genus, about 25^{mm} to 35^{mm} long, $1^{mm}.25$ in diameter anteriorly, more slender posteriorly, ($0^{mm}.5$ in diameter.) Cephalic lobe short, conical; one specimen apparently had two minute ocelli. Mouth large, semicircular. Intestine moniliform, with two simple red blood-vessels running along its whole length and uniting at the constrictions. In the first five or six segments, there are slender vessels of nearly uniform size, which form lateral loops in each segment. Anus terminal, wide, with about ten small lobes. Setæ in four fascicles upon each segment. Those of the lateral fascicles three anteriorly, often but two, short, slightly curved, mostly with minute forked and hooked tips; those of the ventral series in fascicles of four to six, three or four times longer than the upper ones, considerably bent, the ends minutely hooked and forked.

Neepigon Bay, 32 fathoms.

BDELLODEA.

MACROBDELLA DECORA Verrill. (p. 668.)

Collected at Madeline Island by Mr. J. W. Milner.

AULASTOMUM LACUSTRE Leidy. (p. 670.)

Lake Superior, (Leidy.)

SEMISCOLEX GRANDIS Verrill, *var. maculosa.* (p. 672.)

Collected at Madeline Island by Mr. J. W. Milner.

NEPHELIS LATERALIS Verrill. (p. 675.)

Collected with the last species at Madeline Island by Mr. Milner, and a young specimen was also dredged in 6 to 8 fathoms among the Slate Islands.

NEPHELIS FERVIDA Verrill. (p. 676.)

Dredged in 1871, in 8 to 13 fathoms, on the south side of Saint Ignace Island; also from stomach of *Coregonus quadrilateralis* taken at Madeline Island.

CLEPSINE PARASITICA Diesing. (p. 678.)

Judging from the extreme northern and western range of this species, it must occur in Lake Superior.

CLEPSINE PAPILLIFERA Verrill. (p. 683.)

Collected at Bad River by Mr. J. W. Milner.

ICHTHYOBDELLA PUNCTATA Verrill. (p. 687.)

Dredged in 6 to 8 fathoms among the Slate Islands.

TURBELLARIA.

PROCOTYLA FLUVIATILIS Leidy.

Dendrocœlum superbum Leidy, Proceedings Academy Nat. Sci. Philadelphia, vol. v, 1851, p. 288, (*non* Girard.)

Procotyla fluviatilis Leidy, MSS.; Stimpson, Proceedings Academy Nat. Sci. Philadelphia, vol. ix, 1857, p. 23; Diesing, Revision der Turbellarien, Sitzungsberichte der mathem.-naturwissensch. Classe der kais. Acad. der Wissensch. zu Wien, 1861, p. 517; Smith and Verrill, American Journal of Science, 3d series, vol. ii, p. 452, 1871; and Preliminary Report on Dredging in Lake Superior, p. 1025, 1871.

Numerous specimens of this species were dredged in 8 to 13 fathoms among *Cladophora* on the south side of Saint Ignace Island. When living, they were dirty-white, mottled with brown.

It is not uncommon near New Haven, Conn., and in other parts of New England.

MOLLUSCA.

The following list of the mollusks of Lake Superior is largely a compilation from the publications of Say, Haldeman, Gould, Lea, Prime, and Binney, and no sort of revision of the species has been attempted. I have, however, in all cases given the authority for the insertion of the species when I have not observed them myself.

GASTROPODA.

For the identification of several of the following species collected by myself I am indebted to Charles M. Wheatley, esq., of Phœnixville, Pa. For convenience of identification I have added, under most of the species, a reference to Parts II and III of Mr. Binney's Land and Fresh-Water Shells of North America, published in 1865 in the Smithsonian Miscellaneous Collections.

VALVATA TRICARINATA Say.

Binney, op. cit., part iii, p. 9.

From the stomach of white-fish taken at Sault Sainte Marie and the stomach of sturgeon taken at Sand Island.

VALVATA SINCERA Say.

Binney, op. cit., part iii, p. 12.

Dredged in great abundance in 8 to 13 fathoms, among *Cladophora*, on the south side of Saint Ignace; in 4 to 6 fathoms in the cove at the eastern end of the same island; in 6 to 8 fathoms among the Slate Islands; and in 13 to 15 fathoms at Simmon's Harbor; also with the last species from stomachs of white-fish and sturgeon.

MELANTHO PONDEROSA (Say, sp.)

Binney, op. cit., part iii, p. 36.

Lake Superior, (Binney.)

AMNICOLA PALLIDA Haldeman (?).

Binney, op. cit., part iii, p. 83.

An *Amnicola*, found in great abundance in the stomach of white-fish taken at Sault Sainte Marie, is doubtfully identified with this species by Mr. Wheatley.

Amnicola limosa Say, (Binney, op. cit., part iii, p. 84,) probably occurs in Lake Superior, although I do not find it recorded from the lake.

AMNICOLA GRANUM Say.

Binney, op. cit., part iii, p. 86.

North shore, (Gould.) From stomach of white-fish taken at Sault Sainte Marie.

GONIOBASIS LIVESCENS.

Tryon, American Journal of Conchology, vol. ii, p. 33; figs. 205–207, 1866.

From stomach of white-fish taken at Sault Sainte Marie.

PLEUROCERA SUBULARE (Lea, sp.)

Tryon, loc. cit., vol. i, fig. 67, p. 307, 1865.

LIMNÆA STAGNALIS Linnæus.

Binney, op. cit., part ii, p. 25.

Described first from Lake Superior by Say, (under the name *L. jugularis*.) Northern shore, (Gould.)

LIMNÆA COLUMELLA Say.

Binney, op. cit., part ii, p. 32.

Lake Superior, (Binney and others.)

LIMNÆA MEGASOMA Say.

Binney, op. cit., part ii, p. 37.

Lake Superior, (Binney.)

Limnæa palustris Müller, (Binney, op. cit., part ii, p. 44,) doubtless occurs in Lake Superior, since it ranges north to Lake Winnipeg and Great Slave Lake.

LIMNÆA DESIDIOSA Say.

Binney, op. cit., part ii, p. 48.

Northern shore, (Gould.

LIMNÆA EMARGINATA Say.

Binney, op. cit., part ii, p. 51.

Lake Superior, (Binney.)

LIMNÆA CATASCOPIUM Say.

Binney, op. cit., part ii, p. 53.

Northern shore and Fort William, (Gould;) also from the stomach of sturgeon taken at Sand Island.

LIMNÆA CAPERATA Say.

Binney, op. cit., part ii, p. 56.

I found this species in abundance upon the rocky shores of Saint Ignace Island and at Michipicoton Island; also from the stomach of a white-fish taken at Sault Sainte Marie.

LIMNÆA HUMILIS Say.

Binney, op. cit., part ii, p. 63.

Michipicoton, (Gould.)

LIMNÆA LANCEATA Gould.

Binney, op. cit., part ii, p. 68.

North shore, (Gould.) A species which Mr. Wheatley identifies with this was dredged in abundance in 8 to 13 fathoms, among *Cladophora*, on the south side of Saint Ignace Island. These specimens are, however, much less elongated than the figures of *L. lanceata;* approaching, it seems to me, much more nearly to *L. desidiosa.*

PHYSA VINOSA Gould.

Binney, op. cit., part ii, p. 80.

Dredged in 6 to 8 fathoms among the Slate Islands; also, from the stomach of white-fish taken at Sault Sainte Marie.

PHYSA ANCILLARIA Say.

Binney, op. cit., part ii, p. 81.

Dredged in 8 to 13 fathoms, among *Cladophora*, on the south side of Saint Ignace Island; also, common upon the shores of Saint Ignace, Michipicoton Island, and other places on the shores of the lake.

PHYSA HETEROSTROPHA Say.

Binney, op. cit., part ii, p. 84.

Dredged in 4 to 6 and 8 to 13 fathoms at Saint Ignace Island; Black River, Pie Island, Fort William, (Gould.)

Bulinus hypnorum Linnæus, (Binney, op. cit., part ii, p. 99,) probably occurs in the neighborhood of Lake Superior, as it extends far to the north and west of it.

PLANORBIS BICARINATUS Say.

Binney, op. cit., part ii, p. 123.

Sault Sainte Marie, Black River, (Gould;) also, from stomach of sturgeon taken at Sand Island.

PLANORBIS TRIVOLVIS Say.

Binney, op. cit., part ii, p. 115.

Occurs at Marquette and doubtless at other points on the lake.

PLANORBIS CAMPANULATUS Say.

Binney, op. cit., part ii, p. 109.

I found this species at Marquette and at Traverse Island, Keweenaw Bay.

GYRAULUS PARVUS (Say sp.)

Binney, op. cit., part ii, p. 133.

Common in 8 to 13 fathoms on the south side of Saint Ignace Island, and in 6 to 8 fathoms among the Slate Islands; also, from stomach of white-fish taken at Sault Sainte Marie.

Gyraulus deflectus (Binney, op. cit., part ii, p. 129) probably occurs in the vicinity of the lake.

Segmentina armigera H. and A. Adams, (Binney, op. cit., part ii, p. 137,) extends from New York State to Great Slave Lake, and probably occurs with the last species.

LAMELLIBRANCHIATA.

For the identification of most of the species of *Sphærium* and *Pisidium* collected by myself I am greatly indebted to Temple Prime, esq., of New York. References to Mr. Prime's "Monograph of American Corbiculadæ," published in 1865, in the Smithsonion Miscellaneous Collections, are added under the species of that family.

SPHÆRIUM SULCATUM Prime.

Op. cit., p. 33.

Sault Sainte Marie, (Gould.)

SPHÆRIUM AURIUM Prime.

Op. cit., p. 35.

Lake Superior ?, (Prime.)

SPHÆRIUM STRIATINUM Prime.

Op. cit., p. 37.

A very small specimen was dredged in 8 to 13 fathoms, among *Clado-*

phora, on the south side of Saint Ignace Island. It was also found in the stomachs of white-fish taken at Sault Sainte Marie, and in the stomach of a sturgeon taken at Sand Island.

Small specimens of the variety *acuminatum* Prime were dredged in 6 to 8 fathoms, among the Slate Islands.

SPHÆRIUM FABALIS Prime.

Op. cit., p. 40.

Lake Superior, (Prime.)

SPHÆRIUM EMARGINATUM Prime.

Op. cit., p. 43.

Region of Lake Superior, (Prime.)

SPHÆRIUM FLAVUM Prime.

Op. cit., p. 43.

Sault Sainte Marie, (Prime.)

SPHÆRIUM JAYANUM Prime.

Op. cit., p. 46.

Lake Superior, (Prime.)

Sphærium partumeium Prime (op. cit., p. 45) undoubtedly occurs in the region of Lake Superior, and probably many other species will be found there.

PISIDIUM VIRGINICUM Bourguignat.

Prime, op. cit., p. 61.

Dredged in abundance among *Cladophora* in 8 to 13 fathoms on the south side of Saint Ignace Island. Mr. Prime remarks that the specimens are unusually light and fragile.

PISIDIUM COMPRESSUM Prime.

Op. cit., p. 64.

Dredged in 4 to 6 fathoms at the eastern end of Saint Ignace Island.

PISIDIUM ABDITUM Haldeman.

Prime, op. cit., p. 68.

Varieties of this species were dredged among *Cladophora*, in 8 to 13 fathoms, on the south side of Saint Ignace Island; in 6 to 8 fathoms at the eastern end of the same island; and in 15 to 18 fathoms, sandy bottom, at Simmons' Harbor.

PISIDIUM ABDITUM, var. ABYSSORUM Stimpson, MSS.

This is a very small translucent form, dredged by Dr. Stimpson, in Lake Michigan, and by him named in manuscript. Mr. Prime, however, regards it as a stunted form of *P. abditum*. Dr. Stimpson's specimens

were dredged in 40 to 50 fathoms off Racine. In Lake Superior, it was common in the cove at the eastern end of Saint Ignace, on a sandy and muddy bottom, in 4 to 6 fathoms, and abundant among *Cladophora*, in 8 to 13 fathoms, on the south side of that island; among the Slate Islands, in 6 to 8 and 12 to 14 fathoms; at 13 to 15 fathoms on a sandy bottom in Simmons' Harbor; near Copper Harbor, in 17 fathoms, clear sand; in 32 fathoms, very soft clayey mud, in Neepigon Bay; off Copper Harbor, in 62 fathoms; and north of Keweenaw Point, in 82 fathoms, soft reddish clayey mud and sand; and in all the deep dredgings down to 159 fathoms. Below 100 fathoms, however, it was never abundant, and all the specimens from deep water were much smaller and more fragile than the majority of those from shallow water. Apparently, great depths are not favorable to its growth, and it never reaches its full development in such places. It was found in great abundance in the stomachs of white-fish taken at Outer Island.

"*Pisidium abysomus* Stimpson," mentioned, without description, by Hoy, (Transactions Wisconsin Academy, vol. i, p. 100, 1872,) is undoubtedly this variety.

PISIDIUM ROTUNDATUM Prime.

Op. cit., p. 72.

Region of Lake Superior, (Prime.)

UNIO RADIATUS Lamarck.

North shore, (Gould.)

ANODONTA PEPINIANA Lea.

Transactions Amer. Philosophical Society, vol. vi, pl. 16, fig. 51.

North shore, (Gould.)

RADIATA.

HYDRA CARNEA Agassiz.

Proceedings Boston Society Nat. Hist., vol. iii, 354, 1850; Ayres, Proceedings Boston Society Nat. Hist., vol. v, p. 104, 1855; A. Agassiz, Illustrated Catalogue Mus. Comparative Zoöl., North American Acalephæ, p. 197, 1865.

A beautiful *Hydra*, agreeing with Ayres' description of this species, was very abundant at the eastern end of Saint Ignace, upon rocks along the shore and near the surface, frequently completely covering quite large surfaces where they were protected from the direct sunlight, and was also brought up in many of the dredgings from 8 to 148 fathoms. In 32 fathoms, Neepigon Bay, and in 59 fathoms, off Simmons' Harbor, it was brought up in abundance from a soft clayey bottom. In the deep dredgings it frequently came up near the bottom of the clay in the dredge, and was evidently not caught while the dredge was near the surface.

Bathymetrical distribution of species.

I have already alluded to the meagerness of the deep-water fauna of the lake, and to the uniform character of the bottom everywhere below 30 to 40 fathoms. Although our knowledge of the fauna of the lake is still very imperfect, enough facts have been presented to show that very few, if any, of the species which inhabit the lake are confined to the deep waters, and that the change from the shallow to the deep water fauna takes place at a depth of about 30 fathoms, at which depth the character of the bottom and the annual temperature both become nearly uniform. The following table will present more clearly the distribution of the species in depth. Under the first column I have checked those species which are really free-swimming animals, most frequently found at the surface; and under the second, those which live in very shallow waters along the shores, &c. The table is of course very imperfect, even for those species which are included. Most of the species of *Mollusca*, which now appear only in the second column, undoubtedly occur in 4 to 8 fathoms or deeper; but I have only checked the species as far as they have actually been observed at the depths indicated.

	Surface.	Shore.	Depth in fathoms.				
			4–8.	10–20.	30–50.	60–100.	100–169.
INSECTS.							
Chironomus, sp., *a*		×	×	×	×		
Chironomus, sp., *b*				×	×	×	×
Chironomus, sp., *c*			×	×			
Ephemeridæ		×	×	×	×		
Phryganeidæ		×	×	×			
Hydrachna, sp			×				
CRUSTACEA.							
Cambarus, several species		×					
Mysis relicta			×	×	×	×	×
Hyalella dentata		×					
Pontoporeia Hoyi			×	×	×	×	×
Gammarus limnæus			×	×			
Crangonyx gracilis			×	×			
Asellopsis tenax			×	×			
Daphnia galeata	×		×	×	× (?)	× (?)	
Daphnia pellucida	×			×	× (?)	× (?)	
Daphnia pulex ?		×					
Bosmina, sp	×				× (?)	× (?)	
Eurycercus lamellatus?			×	×			
Leptodora hyalina	×		× (?)	× (?)	× (?)	× (?)	
Ostracoda		×	×	×	×	×	×
Copepoda	×	×	×	×	×	×	×
Lernæopoda siscowet	×						
Lernæopoda ? Coregoni	×						
WORMS.							
Lumbricus lacustris			×	×			
Sænuris abyssicola				×		×	×
Sænuris limicola							×
Chirodrillus larviformis				×		×	
Chirodrillus abyssorum					×		×
Tubifex profundicola					×		
Macrobdella decora		×					
Aulastomum lacustre		×					
Semiscolex grandis		×					
Nephelis lateralis		×	×				
Nephelis fervida		×	×	×			
Clepsine papillifera		×					
Ichthyobdella punctata	×	×	×				
Procotyla fluviatilis		×	×				

	Surface.	Shore.	Depth in fathoms.				
			4–8.	10–20.	30–50.	60–100.	100–169.
MOLLUSCA.							
Valvata tricarinata	....	×	....	....	....	....	....
Valvata sincera	....	×	×	×	....	....	....
Melantho ponderosa	....	×	....	....	....	....	....
Amnicola granum	....	×	....	....	....	....	....
Amnicola pallida ?	....	×	....	....	....	....	....
Goniobasis livescens	....	×	....	....	....	....	....
Pleurocera subulare	....	×	....	....	....	....	....
Limnæa stagnalis	....	×	....	....	....	....	....
Limnæa columbella	....	×	....	....	....	....	....
Limnæa megasoma	....	×	....	....	....	....	....
Limnæa desidiosa	....	×	....	....	....	....	....
Limnæa emarginata	....	×	....	....	....	....	....
Limnæa catascopium	....	×	....	....	....	....	....
Limnæa caperata	....	×	....	....	....	....	....
Limnæa humulis	....	×	....	....	....	....	....
Limnæa lanceata*	....	×	×	×	....	....	....
Physa vinosa	....	×	×	....	....	....	....
Physa ancillaria	....	×	×	×	....	....	....
Physa heterostropha	....	×	×	×	....	....	....
Planorbis bicarinatus	....	×	....	....	....	....	....
Planorbis campanulatus	....	×	....	....	....	....	....
Gyraulus parvus	....	×	×	×	....	....	....
Sphærium sulcatum	....	×	....	....	....	....	....
Sphærium striatinum	....	×	×	×	....	....	....
Sphærium fabalis	....	×	....	....	....	....	....
Sphærium flavum	....	×	....	....	....	....	....
Sphærium Jayanum	....	×	....	....	....	....	....
Pisidium Virginicum	....	×	×	×	....	....	....
Pisidium compressum	....	×	×	....	....	....	....
Pisidium abditum	....	×	×	×	....	....	....
Pisidium abditum, var. abyssorum	....	×	×	×	×	×	×
Unio, species	....	×	....	....	....	....	....
Anodonta, species	....	×	....	....	....	....	....
RADIATA.							
Hydra carnea	×	×	×	×	×	×	×

* See p. 702 in reference to the identification of this species.

CORRECTION.—The statement, on page 649, that none of the females of *Pontoporeia Hoyi*, taken in Lake Superior during August and September, were carrying eggs, is incorrect. Three or four among several hundreds of specimens taken August 22 were carrying eggs, and there may be a few in the same condition in other lots; but, among many thousands collected, certainly not one female in a hundred was carrying eggs.

XXVIII.—FOOD OF FRESH-WATER FISHES.

BY SIDNEY I. SMITH.

The following notes were made almost wholly from the contents of the stomachs of a few fresh-water fishes collected by Mr. J. W. Milner.

[Numbers in brackets ([ ]) are the numbers under which specimens were received.]

WHITE-FISH, (*Coregonus albus.*)

[No. 202.] Specimens from Outer Island, Lake Superior, contained great quantities of *Mysis relicta ; Pontoporeia Hoyi ;* and *Pisidium abditum*, var. *abyssorum ;* and with these were a few specimens of dipterous larvæ of the genus *Chironomus ;* a small worm, (*Lumbricus lacustris ;*) *Daphnia galeata ; D. pellucida ;* and a small species of *Planorbis.*

[No. 115.] From Sand Island, Lake Superior, *Pontoporeia Hoyi ;* larvæ and pupæ of *Chironomus ; Valvata sincera ;* and *Gyraulus parvus.*

(No number.) From Sault Sainte Marie, one lot contained scarcely anything but small shells. Among these, *Valvata tricarinata ; V. sincera*, var. *striatella ; Amnicola generosa ; A. palida* (?); *Gyraulus parvus ;* and a species of *Limnæa* were in abundance ; while there were fewer specimens of *Goniobasis livescens ; Physa vinosa* (?), young ; *Sphærium striatinum ;* and *Pisidium compressum.*

[No. 407.] Other specimens contained nothing but the remains of insects, among which were the imagos of two species of *Diptera ;* larvæ and pupæ of *Chironomus ;* larvæ and pupæ of some specimens of *Ephemeridæ ;* great numbers of the larvæ, pupæ, and subimagos of a species of *Hydropsyche ;* and the larvæ of a species of some other genus of *Phryganeidæ.*

[No. 380.] From Ecorse, Mich., specimens contained a species of *Hydrachna*, the leg and the scales from the wing of some lepidopterous insect, and a species of *Limnæa.*

White-fish which I examined at Île Royale, in August, 1871, contained scarcely anything but *Mysis relicta* and *Pontoporeia Hoyi.*

[No. 65.] Ecorse, Mich. Remains of a small fish and several specimens of a species of water-boatmen, (*Corixa.*)

Specimens of *Coregonus quadrilateralis* from Madeline Island, Lake Superior, contained a number of specimens of a leech (*Nephelis fervida*) and a neuropterous larva allied to *Perla.*

These few observations are sufficient to show that the white-fish, like the different species of trout, feeds on a large number of species belonging to very different groups of animals. In this brief enumeration,

twenty-five species are mentioned—nine of insects, four of crustacea, one worm, and eleven of mollusks; and these are undoubtedly only a small part of the species upon which the white-fish really feeds.

SUCKER, (*Catostomus aureolus.*)

[No. 15.] Ecorse, Mich. Many specimens of partially-digested *Asellopsis tenax*, var. *dilata;* and portions of a *Corixa* and of the larva of a dragon-fly.

YELLOW PERCH, (*Perca flavescens.*)

Buffalo. Bones of several small fishes; spawn of some fish; small dipterous larva.

STURGEON, (*Acipenser rubicundus.*)

[No. 118.] At Sand Island, Lake Superior, a specimen contained a few bones of some fish and numerous shells, among which were the following: *Valvata tricarinata; V. sincera; Limnæa catascopium; Physa*, sp.; *Planorbis bicarinatus;* and *Sphærium striaturum.*

Stomachs of *Menobranchus lateralis*, from Ecorse, Mich., contained a number of specimens of a crawfish, (*Cambarus propinquus;*) a neuropterous larva allied to *Perla;* and the remains of a small fish.

XXIX.—NATURAL AND ECONOMICAL HISTORY OF THE GOURAMI.*

By Theodore Gill.

OSPHROMENUS GORAMY.

Synonymy.

Osphromenus goramy, *Lacépède*, Hist. Nat. Poiss., III, 117, pl. 3, fig. 2, 1802; *Gill*, Am. Sportsman, IV, 66, 369, 1874.

Trichopus goramy, *Shaw*, Gen. Zool., IV, 388, pl. 55, 1803.

Osphromenus olfax, *Comm. in Lacépède* Hist. Nat. Poiss., III, 117, 1802; *Hardwicke*, Zool. Journ., IV, 309, pl. 36; *Cuv. & Val.*, Hist. Nat. Poiss., VII, 377, pl. 198, 1831; *Rich*, Brit. Ass. Rep. (Ich. China and Japan), 1846, 251; *Bleeker*, Vissch. Doolh. Kieuw., (Verhand. Batav. Genootschap, XXIII, p.) 10, 1850; *Cantor*, Cat. Malayan Fishes, 88, 1850; *Val.*, Règne An., par Cuv., éd. par disciples, Poissons, pl. 73, figs. 1, 3; *Günther*, Cat. Acanth. Fishes B. M., III, 382, 1861; *and various authors*, Bull. Soc. Zool. d'Acclim., infra cit., 1860–74; Zool. Garten, etc.

Trichopodus mentum, *Lacépède*, Hist. Nat. Poiss., III, 125, pl. 3, fig. 2, 1802. (Based on a bad figure by M. Céré.)

Trichopus satyrus, *Shaw*, Gen. Zool., IV, 391, pl. 35, 1803. (A substitute for *Trichopodus mentum.*)

Osphromenus satyrus, *Bleeker*, Vissch. Doolh. Kieuw. (Verhand. Batav. Genootschap, XXIII), 10, 1850.

Osphromenus notatus, *Kuhl & Van Hassalt, in Cuv. & Val.* Hist. Nat. Poiss., VII, 386, 1831.

Osphromenus vittatus, *Kuhl & Van Hassalt, in Cuv. & Val.* Hist. Nat. Poiss., VII, 387, 1831.

The preceding are only the more important references to the species; others will be found in the foot-notes and in the subsequent text.

A—NATURAL HISTORY.

PREFATORY.

The great interest which has been excited by the gourami, and the numerous attempts to acclimatize or introduce it into distant countries will doubtless render welcome a somewhat elaborate article on the species, and a practical application of the lessons of experience in connection with it.

The literature on the fish is very voluminous, and numerous articles have been written upon it; in the Bulletin de la Société Impériale Zoologique d'Acclimatation alone, there are about one hundred references in the indices to articles and notices in the various volumes. These and many other papers have been consulted, and our readers are furnished with the results of experiments and observations to date. Especially

* This article is reprinted, with slight modifications by the author, from "The American Sportsman," for September 12, 1874, (A,) and October 31, 1874, (B,) by permission of the editor and proprietor (W. F. Parker, esq.) of that paper.—S. F. Baird.

are acknowledgments due to the articles cited in the foot-note;* to Colonel Nicolas Pike, our late very efficient consul to Mauritius, to whom the Smithsonian Institution is indebted for many specimens; and to extracts from an article of Mr. Clarke.

NAME.

Osphromenus goramy is the true and first-published scientific name given to the celebrated gourami, and was conferred by Lacépède, who accepted a manuscript-name devised by Commerson for the genus, and proposed a modification of the best-known vernacular name for the species. *Osphromenus olfax*, a name suggested in the manuscript of Commerson, was published by Lacépède as a synonym. The name *Osphromenus* was bestowed by Commerson by reason of an erroneous idea which he entertained, (that the labyrinthiform apparatus was an adaptation for smelling,) and was derived from the Greek *οσφρομαι*, to smell. Commerson's idea arose from his perception of some analogy in appearance between the labyrinthiform apparatus and the ethmoid bone of man.

FORM, ETC.

The gourami has an oblong-oval form. The snout is produced, and the forehead in front of the eyes concave but behind convex, and it becomes more and more so with advancing age, (as will be noticed by comparison of figures of young and old here given). The lateral line is continuous from the shoulder to the base of the caudal fin. The dorsal fin is considerably smaller than the anal; the former commencing far behind the head, ending some distance in advance of the caudal, and furnished with eleven to thirteen spines, and eleven or twelve articulated rays; the anal commencing near the base of the ventral, extending to and connected with the base of the caudal fin, and supplied with nine to

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* RUFZ DE LAVISON. *Sur quelques tentatives d'acclimatation du gourami (Osphromenus olfax) dans divers pays.* <Bulletin Soc. Imp. Zool. d'Acclim. (Paris), viii, 1861, pp. 392–403.

VINSON (Dr. Auguste). *De l'acclimatation du gourami à l'ile de la Réunion, et des moyens d'acclimater ce poisson en Algerie et dans le midi de la France.* <Bulletin Soc. Imp. Zool. d'Acclim. (Paris), viii, 1861, pp. 509–514, 541–546.

BARTHÉLEMY-LAPOMMERAYE. *Nouvelle tentative d'introduction du gourami d'île Maurice en France, entreprise par M. Lienard.* <Bulletin Soc. Imp. Zool. d'Acclim. (Paris), x, 1863, pp. 739–740.

COSTE. *Instruction pour le transport des gouramis.* <Bulletin Soc. Imp. Zool. d'Acclim. (Paris), 2e série, ii, 1865, pp. 76–80.

BARTHÉLEMY-LAPOMMERAYE. *Sur l'introduction récente du gourami en France, et instructions à cet sujet. Lettre adressée à M. le président de la Société Impériale d'Acclimatation.* <Bulletin Soc. Imp. Zool. d'Acclim. (Paris), 2e série, ii, 1865, pp. 195–203.

DABRY (P. Thiersant). *Note sur le transport des gouramis.* <Bulletin Soc. Imp. Zool. d'Acclim. (Paris), 2e série, v, 1868, pp. 591–592.

——— *Histoire naturelle du gourami.* <Bulletin Soc. Imp. Zool. d'Acclim. (Paris), 2e série. viii, 870, pp. 671–688.

twelve spines and nineteen to twenty-one branched rays; the caudal fin is rounded behind; the ventrals have five rays, (besides the spine,) and the one next to the spine is much prolonged, especially in the young. The opercular bones are unarmed, having neither spines nor serratures. The color is brownish, with faint oblique bands in the young, but unicolor in the adult, with a blackish spot at the base of the pectoral fin.

GEOGRAPHICAL RANGE.

The gourami has been an inhabitant from time immemorial of the fresh waters of Cochin China, on the mainland of Farther India, as well as the islands of Java, Madura, Sumatra, and Borneo, and may, therefore, be presumed to be indigenous to all those localities. It is also found in Malacca and the adjoining small island Penang, or Prince of Wales Island, but is said to have been introduced into those places from Cochin China. The history of its successful introduction into the islands of Mauritius and Bourbon (or Réunion) is a matter of record and well known. Attempts have likewise been made to introduce it into the West Indian island Martinique, the French South-American colony Cayenne, the Cape of Good Hope, Australia, Egypt, and France, but hitherto without satisfactory results. Details respecting these attempts will hereafter be given.

SIZE.

The gourami is potentially almost one of the largest fresh-water fishes found in any part of the world, if we may credit the statements of certain authors; for it has been reported (by Baron de Roujoux) that in their original habitat they sometimes attain the length of 5 or 6 feet and a weight of 50 kilograms, that is, somewhat more than 110 pounds. It must be remembered, too, (and will be recognized by reference to the illustrations,) that they have bodies deep and stout in proportion to their length. While it is barely possible that they may occasionally, under exceptional conditions, attain such a size, they generally fall far short of it; and at the islands of Bourbon and Mauritius, they have never been found even approximating that size; according to Dr. Vinson, at Bourbon they rarely exceed 8 to 10 kilograms, (*i. e.*, 17.63 to 22.04 pounds,) although they occasionally attain a weight of 16 kilograms, (*i. e.*, 35.27 pounds.) The largest that Dr. Vinson had seen measured 92 centimeters (*i. e.*, about three feet) long, and 38 centimeters (*i. e.*, 15 inches) in depth. They are even considered very large if they weigh 12 to 14 pounds and measure about 2 feet in length. They probably continue to grow indefinitely to some extent under favorable conditions, and hence, if they have really been seen of the size claimed, they may have been of great age.

GROWTH AND AGE.

The fry, or newly-hatched, is, of course, very small, and proportioned

to the size of the egg (about half an inch, more or less);* at the end of the first year, it has grown to a length of about 4 inches; in the second, to about 7 or 8; and in the third, to about 10 or 11. In the third year, it is sexually developed and commences to spawn. Their growth, however, continues indefinitely, conditioned by the nature of their home. If their quarters are confined and the water cold, they increase slowly and do not thrive; but if the water is warm, well aerated, and extensive, and otherwise appropriate, they flourish and increase rapidly. They continue to grow for years, and attain a very considerable age; and in the island of Martinique, the last introduced therein was killed for the table twenty-seven years after its arrival, and at the time of its capture measured about a meter (or 39 inches) in length.

STATION AND TEMPERATURE.

The gourami, in its native country, (Anam or Cochin China,) is found in brackish as well as fresh waters, and even prefers the former, according to M. Pierre, the director of the Zoological and Botanical Garden of Saigon, (see Bulletin Imp. Zool. Soc. d'Acclim., 1869, p. 45). According to other authors, it is found in running streams, lakes, and ponds, but flourishes best in the last, especially when they are stocked with aquatic plants and have deep and sheltered holes to which the fishes can retreat, and which they especially avail themselves of in cold weather. The countries in which it thrives are in the intertropical belt, with an annual mean temperature, says M. Dabry, of about 24° to 26° centigrade, (*i. e.*, 75°.20 to 78°.80 Fahrenheit,) and with the mean of the winter not much less than 19° centigrade, (66°.20 Fahrenheit,) while the coldest weather is rarely below 14° or 15° centigrade (57°.20 to 59° Fahrenheit) above freezing. As the temperature of a country is an all-important element to be taken into consideration in estimating the probabilities of success in attempts to introduce this fish, the following table of the temperatures of the year and its several seasons in the countries in which the gourami is now found is reproduced from Mr. Dabry's article on that fish. (Bulletin Imp. Zool. Soc. d'Acclim., 1870, p. 676.) The first column of figures in each double column represents the temperature in degrees centigrade, as given by Mr. Dabry, and the second the equivalents in degrees of the Fahrenheit thermometer.

*According to Mr. Clark, the newly-hatched are less than half an inch, and according to Mr. Dabry 2 to 4 centimeters, (*i. e.*, about an inch, more or less,) long; the former statement appears to be the most probable.

TABLE OF ATMOSPHERIC TEMPERATURES OF NATIVE AND FOSTER COUNTRIES OF THE GOURAMI.

Cities and countries.	Annual mean.		Winter mean.		Spring mean.		Summer mean.		Autumn mean.		Mean of coldest month.		Mean of warmest month.		Greatest cold.		Greatest heat.		Authorities.
Port Louis (Mauritius)	24. 9	76. 82	21. 6	70. 88	23. 8	74. 84	28. 1	82. 58	26. 0	78. 80	21. 1	69. 98	28. 4	85. 12	19. 4	66. 92	32. 7	90. 86	Martins, in Kæmptz.
St. Denis (Réunion)	25	77	22. 6	72. 68	24. 9	76. 82	26. 7	80. 06	25. 6	78. 08	22. 1	71. 78	27. 1	80. 78	15?	59?	......	......	Martins, Vinson.
Batavia	26. 8	80. 4	26. 2	79. 16	26. 8	80. 24	27. 2	80. 96	29. 1	84. 38	27. 9	82. 22	27. 8	82. 04	......	......	......	......	Martins, Bergham.
Trincomalee (Ceylon)	27. 4	81. 32	25. 7	78. 26	28. 4	83. 12	28. 9	84. 02	29. 2	84. 56	25. 4	77. 72	29. 2	84. 56	......	......	......	......	Martins, Bergham.
Penang	28. 3	82. 94	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	Bergham.
Malacca	30. 2	86. 36	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	Bergham.
Sumatra	29. 5	85. 10	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	Bescherelle.
Borneo	28	82. 40	......	......	......	......	......	......	......	......	......	......	......	......	......	......	35	95	
Havana	25	77	22. 6	72. 68	24. 6	76. 28	29. 4	84. 92	25. 6	78. 08	21. 9	71. 42	27. 5	81. 50	......	......	......	......	Bescherelle.
Cayenne	25	77	......	......	......	......	30	86	......	......	20	68	32	89. 60	......	......	35	95	Martins.
Martinique	25	77	......	......	......	......	......	......	......	......	......	......	......	......	17	62. 60	35	95	Chauvallon.
Surinam	25	77	......	......	......	......	......	......	......	......	......	......	32	89. 60	......	......	......	......	Bescherelle.

Such are the temperatures of the regions where (and where only) the gourami flourishes; the table may be allowed, in the main, to speak for itself, but a slight commentary may serve to enforce its significance. The island of Bourbon, (or Réunion,) in the coldest months of the year, (June, July, and August,) near St. Denis, has a temperature not lower than 57° to 59°, (Fahrenheit,) and in the warmest months (January and February) the thermometer indicates a temperature of about 80° near the level of the sea, and at the heights in the vicinity more than 62°. And yet gouramis kept at such elevations, although they lived, and for about thirty years, never propagated, but when transported to the streams of the lowlands soon increased and multiplied; and as there was no other apparent cause, the barrenness in the elevated regions was attributed, and apparently with justness, to the insufficient warmth. Let it then be borne in mind that a temperature of not less than 57° retarded the growth and prohibited the multiplication of the gourami.*

Such, at least, was the general inference from the observed facts and experience respecting the fish in the isle of Bourbon. So sensitive, too, are they to cold, that during the cold spells in Bourbon and Mauritius, they bury themselves in the mud or take shelter in the weeds. So fond, on the other hand, are they of heat and sun-light, that in the hottest days of summer they bask in the sun, and, ascending to the surface, protrude their mouths and swallow atmospheric air. The last characteristic, however, is doubtless a concomitant of their organization, in common with the other members of the family.

FOOD.

The gourami is omnivorous in its appetite, taking at times flesh, fish, frogs, insects, worms, and many kinds of vegetable; and on account of its omnivorous habit, it has been called by the French colonists of Mauritius *porc des rivières*, or "water-pig;" it is, however, essentially a vegetarian, and its adaptation for this diet is indicated by the extremely elongate intestinal canal, which is many times folded upon itself. It is said to be especially fond of the leaves of several araceous plants belonging to the genera *Caladium*, *Arum*, and *Pistia*; but it also devours, with not much inferior relish, cabbage, radish, carrot, turnip, and beet leaves, lettuce, and most of the wild plants which grow in the water, and it can secure for its use the leaves of plants that grow on the banks and a slight distance out of the water. It also takes wild rice, maize, potatoes, arrow-root, manioc, bread, and analogous articles.

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* It has even been asserted that a fall of the temperature to 66° (Fahrenheit) caused death on the way from Mauritius to Australia; and in the Museum of Natural History of Paris, in a decrease to 59°, death commenced. Even if some other conditions concurred to produce death, the circumstances of their death without any other assignable cause show how delicate they are.

MOVEMENTS.

In its movements the gourami is slow, and is said to swim along with a certain "majesty of demeanor," (majesty probably being associated with slowness); it rarely hastens toward a meal, but proceeds slowly and leisurely onward. If, however, aught frightens the fishes, or they are disturbed, they at once show that swiftness is not incompatible with their organization, and they dart away with great velocity. They are also possessed of great saltatorial agility, and if confined in narrow quarters are prone to leap out, and when pursued they will also attempt to escape by leaping out of the water. This is manifested when they are fished for with nets, and, according to Colonel Pike, unless the net is held a foot or two above the water, they will leap over it to a distance of several feet outside, and even when caught and laid on the ground, unless attended to, they will repeatedly leap upward and "batter themselves to pieces," for they are very tenacious of life.

SPAWNING AND NESTING.

In the sexual relations, and the care which it takes of its eggs, the gourami resembles the sunfishes of temperate North America and the cichlids of tropical America and Africa. The spawning-season falls in the autumn (March and April) and spring (September and October) of the transequatorial islands of Mauritius and Bourbon. When that time has come, the males and females pair off, and each pair select a suitable place wherein they construct a rude nest. "Like all intelligent animals, they will only propagate when insured a suitable temperature for the eggs and young, a fit retreat for the building of the nest, with plants and mud for its construction, and aquatic plants suitable for the food of the young." The bottom selected is muddy, the depth variable within a narrow area; that is, in one place about a yard, and near by several yards deep. They prefer to use for the nest tufts of a peculiar grass, (*Panicum jumentorum*,) which grows on the surface of the water, and whose floating roots, which rise and fall with the movements of the waters, form natural galleries, under which the fish can conceal themselves. In one of the corners of the pond, among the plants which grow there, the gouramis attach their nest, which is of a nearly spherical form, and composed of plants and mud, and considerably resembles in form those of some birds.

The nests, of course, vary in size in proportion to the fishes, but the usual size is somewhat less than a man's hand in length, (about 5 or 6 inches). The fishes are employed some five or six days or a week in building, and their task is rendered easier, when the pairing-season has arrived, by placing in the water, almost at the surface, branches of bamboo, (*Bambusa arundinacea*,) to which are attached bundles of fine dog's-tooth grass. The gouramis take this grass, and with it form their nests in the branches of the submerged bamboo, in a manner analogous to

that with which the common silk-worm avails itself of the branch which is presented for it to make its nest on. When the nest is completed, the female deposits her eggs, which in a moderate-sized individual amount to about 800 to 1,000. After the eggs have been deposited and fecundated, and while they are hatching, the parents remain near, jealously guarding them, and rushing with vehement fury at any ordinary intruder near their domains, and thus they continue to guard the young for a time after they are hatched.

YOUNG.

The eggs are soon hatched, (within a fortnight, according to Mr. Clark,) and in the nest the young find (1) a refuge where they are free from a thousand dangers by which they would be otherwise threatened during the first days of their life; and (2) in the macerated vegetable matter of which their nest is partly composed, they obtain their earliest food, and that which is most suitable to them in their most delicate condition. Soon, however, they make short excursions from the nest, but under the guidance of the parent-fish, who is prepared to give them aid in case of need. They do not soon disperse, but keep together in shoals. The young, it is said, for some time retain the yelk-bag, and the ventral fins are very conspicuous, much exceeding in length the fish; and as they grow only to a limited extent *pari passu* with the fish, they gradually lose their relative length, and the difference between even the adolescent fish and those of a more advanced age is considerable, as will be perceived by reference to the illustrations.

FLESH.

The gourami has always been held in high esteem for the excellence of its flesh, at least among the Europeans and colonists. Commerson, to whom we are indebted for our first acquaintance with the fish, in rapture declared that he had never tasted among either salt or fresh-water fishes any more delicious, ("*nihil inter pisces tum marinos tum fluviatiles exquisitius unquam degustavi,*") and subsequent gourmands have re-echoed the sentiment. Its flesh is, according to several authors, of a light-yellow straw-color, firm, and easy of digestion. They vary in value according to the nature of the waters inhabited; those taken from a rocky river being much superior to those from muddy ponds, but those dwelling at the mouths of rivers, where the water is to some extent brackish, are the best of all. Again, they vary with age, and the large overgrown fishes are much less esteemed than the small ones; they are in their prime when three years old. Dr. Vinson says the flavor is somewhat like that of the carp, and, if this is so, we may entertain some skepticism as to its superiority; but the unanimous testimony in favor of its excellence naturally leads to the belief that the comparison is unfair to the gourami.

B—THE INTRODUCTION AND ATTEMPTS TO INTRODUCE THE GOURAMI INTO FOREIGN COUNTRIES.

AUTHORITIES.

In this chapter are given, in more or less detail, accounts of the attempts to introduce the gourami into various countries. These have been chiefly compiled, as before indicated, from the "Bulletin de la Société Zoologique d'Acclimatation," and to enable ready reference to be made for verification or further details of the facts here mentioned, references are added in parentheses, the larger numbers (e. g., 1870) indicating the year of publication in the Bulletin, and the smaller numbers the pages of the annual volumes.

EAST INDIAN ISLANDS.

No other fish has been the subject of such earnest and oft-repeated attempts to introduce and acclimatize in foreign countries as the gourami. Originally, it is claimed, (by Mr. Dabry,) peculiar to Cochin China and the neighboring countries, it is said to have been introduced at the commencement of the last century in Java, and thence into the neighboring islands Madura, Penang, Borneo, Sumatra, and Molucca. No positive data, however, have been published—or, at least, are known to the writer—of the details of those efforts, and the accounts are therefore somewhat apocryphal.

ISLAND OF MAURITIUS.

The first well-authenticated transportation and introduction of the fish into a foreign country were into the island of Mauritius, (then called "Isle of France,") in 1761, at that time under the dominion of the French.

In that year, several naval officers—chief of whom were Captains De Surville, Joannis, and De Magny—took some fishes to the island, but, it is said, rather for the gratification of the sight and for exhibition in vases than with reference to its eventual naturalization in the island; these were confided to Céré, (who has been accredited with the introduction of the goldfish into France,) who was at the time mentioned commander of the French troops in the island, and he especially interested himself in the introduction of the species. The fish placed in the ponds propagated; some escaped into the contiguous streams, and the species had become already domiciliated in the island when Commerson, the naturalist-traveler, visited it in 1770. According to Commerson, the fishes introduced had been brought from China; but according to others, and especially M. Carpentier-Cossigny, (and with greater probability,) they were carried from Batavia.

ISLAND OF BOURBON OR RÉUNION.

The gourami was next introduced into the neighboring island of Bourbon or Réunion in 1795, through the efforts of M. Desmanières, a

resident of the island, and who imported specimens from Mauritius. His experience has been given by M. Vinson, and, on account of its important bearing on the subject of its acclimatization in other lands, is repeated in his own words. M. Desmanières had "on his estate of Bellevue, situated on the upland of the quarter Sainte-Suzanne, a magnificent natural body of water, with two islets abounding in aquatic plants. Everything appeared to be favorable for the raising of the gourami, but the low temperature at this part of the island had not been taken into consideration. The fishes lived, but did not propagate. M. Desmanières at first thought that the large size of the pond might be the cause of this, and he caused to be made two vivaria, which may yet be seen, and which were supplied by the large pond. In these vivaria, the gouramis were placed; but the result was still unsatisfactory. He received from the isle of France additional fishes, but even then had no success. Finally, having transferred his fishes into a vivarium near the sea-shore, he succeeded in inducing propagation. This experiment had, however, taken thirty years; and during this time success in propagating the species in the island had become despaired of. As has been seen, acclimatization often depends on causes very simple in appearance, but which are only discovered after a long time."

In other words, in a place where in the coldest months the temperature does not ordinarily fall below 67° Fahrenheit, the species did not thrive and propagate. In the warmer waters of the lowland, however, it immediately began to multiply, and is now abundant; it is the object of regular care and cultivation in vivaria or ponds, and the source of a regular income; the wealthy proprietors or planters of some districts have, too, each their own private ponds.

WEST INDIES.

The next earnest attempt to introduce the species into a distant country was made at the instance of M. Moreau de Jonnes, who, in 1818, induced the "minister of marine" of France to order the transportation of specimens to the French possessions in the West Indies. Accordingly, in April, 1819, a hundred small fishes were intrusted to the care of M. de Mackau, captain of a storeship, Le Golo, and the interest and zealous care manifested by that officer were rewarded by the comparatively slight loss of only twenty-three fishes during the entire voyage to the West Indies; and when it is recalled that a slight blow, an abrasion of the sides, or loss of a scale, may cause death, and the difficulty of adjusting the supply of fresh water, &c., to their necessities is taken into consideration, the small percentage of the loss must be considered as remarkable. Of the seventy-seven which remained alive, twenty-six were distributed to the islands of Martinique and Guadeloupe each, and twenty-five to the colony of Cayenne. The fortunes of the strangers in their new places of abode were various. Cuvier and

Valenciennes, in the seventh volume of their "Histoire Naturelle des Poissons," published in 1831, acknowledge the reception of one of the fishes originally taken from Isle-de-France to Cayenne. The belief that their acclimatization in America had succeeded has even found utterance in the statement as a fact which has obtained currency in several publications. Although the fishes introduced continued to live, none seemed to be fruitful in their new quarters, and there is no published evidence that any individuals of the species are now living in America. We have the fullest and most authentic details concerning its fate in Martinique.

The little fishes, on their arrival at Martinique, were placed in a large basin of fresh water; the largest of them was only about three French inches long. Some months after, they were transferred to a small pond in the botanic garden of Saint Pierre; all were still alive and healthy, and had attained a length of from 10 to 12 inches. Their subsequeny increase was, however, much less rapid, and after six years, thet had little more than doubled that length, for in 1827 the largest had only gained a length of from 24 to 27 inches. The subsequent rate of increase was still less rapid, as might naturally be supposed; and the last survivor of the original twenty-six, which was served on the table in 1846, twenty-seven years after its arrival at Martinique, measured about a meter, or somewhat more than 39 inches in length. None of these fishes had been able to propagate their race in the island during all this time. Five years after their introduction, a formal announcement was indeed made that numerous young gouramis had made their appearance in two broods, at intervals of only six months; but it was soon discovered that the supposed young gouramis were native fishes that had gained entrance into the preserves of the gouramis. The sudden revulsion from the hope and high expectations to which the apparent success had given rise, to chagrin and despair, unhappily reacted on the poor fishes, and was doubtless enhanced by the ridicule which the exposure of the nature of the discovery entailed on the historian of that discovery, and which engendered a proverbial expression in the island. The prospect of propagating the gouramis appearing hopeless, one after another was caught and served up on the table of the governor when a distinguished guest was to be entertained, and thus was the last disposed of in 1846. Although equally full details have not been published concerning those introduced into Guadeloupe and Cayenne, no greater success appears to have rewarded the attempts to propagate the species.

As it has repeatedly been affirmed (1867, 551) that the gourami has been acclimatized in, or is a native of, South-American waters, it may be well to state here that there is no other foundation for such statements than the existence in those waters of fishes belonging to the family of icchlids, which have some superficial resemblance to the gourami.

FRANCE.

The most careful and persevering attempts have been made to introduce the gourami into France, and it was the subject of the most zealous efforts for a number of years on the part of the Acclimatization Society of Paris. In 1862 and 1867, prizes were offered (for the introduction and acclimatization of a new food-fish into the fresh waters of France, from Algeria, Martinique, or Guadeloupe) of five hundred francs for any fish except the gourami, and double the amount in case of that species, the competition being open under the last offer until the 1st of December, 1870. From the numerous references in the bulletin of that society, (Bulletin de la Société Impériale Zoologique d'Acclimatation,) the following account is drawn up, the authorities therein for the statements of facts being inclosed in parentheses.

As early as 1804, it seems an attempt had been made to introduce the fish into France. In that year the celebrated Peron, on his return from the voyage of circumnavigation in the corvette Le Géographe, stopped at the island of Mauritius, and there took on board a hundred gouramis, but these all died in the Mozambique Channel, partly in consequence of the bad quality of the water with which the receptacle containing them was renewed and partly on account of the fall in the temperature, (1859, p. 339; 1861, pp. 25–26*).

Nearly at the same time another unsuccessful attempt was made by Bailli de Suffren, (1861, 545,) and he also recommended that it should be attempted by stages, that is, by acclimatizing them in, and then transferring them from, intermediate places. In 1820, another consignment of fish was taken on the corvette Le Relief; but notwithstanding the care taken by the commander, Baron Melius, no better luck attended the attempt (1870, 686).

Not for many years were any further endeavors made to introduce the gourami into France. In 1856, however, the Messieurs Lienard, (father and son,) planters of the island of Mauritius, wrote to the Acclimatization Society of Paris, announcing their intention to send, when the opportunitity offered, living individuals of " the fish known under the name of gourami" (1856, 204; 1857, xlvi). Hopeful anticipations were entertained that these attempts would, at no distant day, be successful (1860, i). No consignments by the Lienards were made, however, till 1861, when a number (50) were confided to the care of Dr. Perrot de Chamarel, who went by the way of Suez to Marseilles, and arrived early in July at the latter city, with only five of the lot (1861, 367, 422, 473). These, apparently, were subsequently given to M. Paul Gervais, then of Montpellier, as he, in 1867, recalled that he had received from Dr. Perrot de Chamarel five fishes, the survivors of a lot of twenty-five, with which Dr. Perrot started from Mauritius. These five were

* See, also, GIRARD, *Vie et travaux de François Peron.*

intrusted by Professor Gervais to the superintendent of pisciculture of the department of Herault, but lived only a few weeks (1867, 551).*

Monographs on the habits and best means of caring for the gourami were now presented by Messrs. Rufz de Lavison, Roujoux, and Vinson, and published in the Bulletin of the Acclimatization Society, (1861, 290, 355, 392, 403, 509, 514, 541, 546); and the success in bringing the five specimens as far as Marseilles encouraged the friends of the fish. A fresh consignment was made by M. Lienard to M. Barthélemy-Lapommeraye, at Alexandria, in February, 1862, (1862, 135, 150); but at the same time the news of their death after their arrival in Egypt was received from M. Lienard, (1862, 142, 150).

Another volunteer (M. Manés, of the island of Réunion) soon after tendered his services,(1862,798, 898, 917,) and several attempts were actually made by him; a first early failed (1862, 917; 1863, 120). He, however, had greater hopes of success in transportation of the fecundated ova than of the developed fish.

Soon after (in March) a number of fish were sent by M. Manés, of the island of Réunion, in care of M. Rignolet (1863, 307,) and some arrived living at Cairo, but all succumbed on the way from that place to Algeria (1863, 627). M. Manés then, despairing of sending them alive to France, proposed to consign some to the care of the Khedive of Egypt, by whom they could be ultimately forwarded to France (1863, 627). This intention he carried out in the following year (October, 1864).

But early in November of this year, M. Lienard left Mauritius with ten fishes, and leaving five of them in Egypt in care of M. Coulon, at a country-house near Cairo, he arrived at Marseilles with the rest; but four of the five died soon after his arrival, on account of the changes in the wind and temperature. The sole survivor was confided to the care of M. Barthélemy-Lapommeraye (1863, 738, 764). Again, in October, 1864, M. Barthélemy-Lapommeraye was intrusted with the care of a lot of seven gouramis, which had arrived in Marseilles, and had been sent by M. Autard de Bragard to M. Lienard for the French Society of Acclimatization, through the intervention of M. Georges Aubin (1865, 615).

M. Manés subsequently sent nests of the gouramis, containing their eggs, one in January, 1865, (1865, 52,) and a second in May, (1865, 356); but no records of their fate were published by the society. A second time, however, after all these trials, a lot of living fishes were received in France. M. Autard de Bragard, of the island of Mauritius, and ex-president of the Acclimatization Society of that island, took with him nineteen fishes from the island in a large glass vase, and arrived at Marseilles with eleven of the lot on the 15th of April, (1865, 195–313); but they all died very soon after their arrival (1865, 199–358). Another lot of about two hundred fishes, sent at nearly the same time, was still less

* Notwithstanding the discrepancies noted, the two accounts have reference apparently to the same lot.

fortunate, all having died at Suez (1865, 357, 425, 549); equally unsuccessful were consignments made by M. Autard de Bragard (1865, 488; 1866, 485–487). In the last case, we are told by M. Berthelin, who took charge of them, twenty had been selected the evening before the departure of the vessel, those selected being about three inches; these were placed in the vessel in a zinc vase, in a dark place, and the water was renewed every day with river-water; but, in spite of all, the fishes soon died, two on the day after leaving port, twelve in the night of the second or third day, and two on the next succeeding one, while the four remaining were transferred into a porcelain vase and lived a number of days, (from the 18th to the 30th of May,) but finally succumbed (to the excessive heat, it was supposed) in the harbor of Aden (1866, 485, 487, 493, 569). M. Berthelin added suggestions for future guidance, and recommended Egypt as an intermediate station for the acclimatization of the gourami (1866, 598).

Again, in 1867, gouramis were brought living into France. First, M. Berthelin and M. Grandidier, in May, arrived at Marseilles with sixteen fishes out of an original lot of one hundred; six, however, soon died, and the rest followed some time after (1867, 441); and again M. Autard de Bragard was successful, reaching Marseilles (near the end of July) with five fishes out of twelve with which he embarked at Mauritius, and these were even received in Paris, and confided (July 17) to the care of M. Duméril in order to be kept in the reptile-house of the Museum of Natural History (1867, 550–552). These thrived for some time (1867, 640), and until October, when on account of the fall of the temperature, they suddenly succumbed—one on the 4th, two on the 5th, and the last two on the 6th. The temperature of the water, nevertheless, had not declined lower than 13° centigrade (55.40 Fahrenheit); and that cold was the cause of death was rendered evident by the sluggishness of the fishes near this temperature, and their revival when warmer water was injected, to be again succeeded by depression when the temperature again fell (1868, 352).

An attempt was also made from another quarter to give France the coveted fish. M. Henry Rozy sent from Bantam, in the island of Java, fifteen gouramis, and also the branchlets of a tree containing nests of the fish; eleven of the fishes were received at Marseilles alive, having made the long voyage without apparent detriment, but on the night of their arrival, the cold being too great for them, they died; nothing has been recorded as to the fate of the eggs (1871, 646).

Invoices of gouramis appear to have been also received, within the last year or two, by M. Pierre Carbonnier; but a failure of reception of the numbers of the "Bulletin de la Société d'acclimatation," containing the accounts, prevents us from giving full information at this time. Mr. Carbonnier, however, seems to have had unusual success in keeping his fishes alive. In August, twenty-two specimens of anabas and six gouramis were brought from Calcutta to Galles by M. Paul Carbonnier, and

were sent to the father in a glass vessel. The water was not changed on the route, and no one took special care of it. Ten anabas and three gouramis arrived, living, at Marseilles on the first of August. In the same vessel were found the skeletons of those which had died on the way. This success, says M. Carbonnier, is of importance, as it furnishes proof that all fishes with labyrinthiform pharyngeals can dispense with taking oxygen through the medium of water, and are able to avail themselves of the atmospheric air directly. Those that died on the way from Marseilles probably died from hunger rather than from insufficient aeration or other active malady (1874, 526–527).

A very recent record of unexpected success in the preservation of the gourami in the open air, during the winter, may seem to almost nullify the experience of others, and the inferences recorded in the preceding chapter. The account referred to has been published in the "Bulletin de la Société d'acclimatation" for March, 1874, and the following is almost a literal translation of the passages.

"M. Turrel writes from Toulon: The water-basin of our garden is enriched with two gouramis, which have for two years supported the climate of our Provence under conditions which appear to me to deserve to be mentioned. But before entering upon the details of this introduction, I ask myself if the fishes in question are truly gouramis. In form, they resemble carps; in dimension, they are nearly fifteen centimeters in length; their color is a very brilliant bronze copper. The following is the history of their introduction as it has been furnished to myself:

"In 1872, M. Daniels, second captain of the mail-steamer, took from Singapore for Ciotat (Bouches-du-Rhône) nearly two hundred young gouramis, of which only four survived the passage. These four were placed in an unwalled basin, having a depth of about two meters, and on the bottom of which aquatic plants were growing. In this body of water, the four fishes have passed two winters; in that season plunging into the bottom to avoid the attacks of cold, and supporting under these conditions 4° (39°.20 Fahrenheit) of temperature.

"Two of these fishes were given to me by a friend of M. Dauveld, who had obtained them to place in the basin. I received them the 13th of February, and placed them immediately in the basin of our garden, which has little depth and little extent, but is provided with a southern exposure, and protected against radiation by rock-work in the form of a grotto" (1874, 225–226).

The doubt involved in this case is as to the species of fish experimented with, and the doubt apparently conceived by M. Turrel may be pardoned in others until the fishes have been examined by an experienced ichthyologist.

While the French Society of Acclimatization was year after year attempting to introduce the gourami into France, frequent tenders of service were made by affiliated societies or individuals. Among others, the Baron Dunast suggested to the society a small rivulet in Sicily—the Anapo, or, as it was anciently called, the Anapus—as one which ap-

peared to him to combine all the most favorable conditions for such attempts (1864, 215; 1866, 680; 1867, 228); and ultimately, in response to a letter from the president of the Paris society, the Society of Acclimatization and Agriculture of Sicily, through its president, Baron Anca, appointed a commission to report on the subject, (1867, 282,) which confirmed the favorable opinion entertained by Baron Dunast, (1867, 552, 753.) An elaborate report was published by the Italian society on the subject, but their recommendations appear never to have been carried into effect.

All the attempts to acclimatize the gourami in France have thus far proved to be failures; and (if the physological data obtained from a wide experience are any guide) are likely to be equally so in the future; and the Acclimatization Society has recognized this truth in the discontinuance of offers of specific prizes for the introduction or acclimatization into its waters of the gourami. The society, however, evidently still entertains hope of success for several French provinces; as, in 1873, it renewed its offers of prizes (which have been repeated several times) relative to this species. The premiums offered are, severally: (1) 500 francs for the *introduction* into the fresh waters of Algeria of a new food-fish; (2) 1,000 francs for the *acclimatization* in the fresh waters of Algeria of a new food-fish; (3) 500 francs for the *introduction* into the fresh waters of Guadeloupe and Martinique of a new food-fish; and, (4) 1,000 francs for the *acclimatization* in the fresh waters of Guadeloupe and Martinique of a new food-fish. The time for competition is in each case open till December, 1880; and the amounts offered are in each case doubled, in case the fish *introduced* or *acclimatized* is the gourami.

ALGERIA.

Efforts to introduce the fish into the French colony of Algeria were initiated in 1863 by a letter from M. Tourniol, of Melianah, (repeated in 1865, 489,) who offered to the French Acclimatization Society the use of his fish-basins to receive any specimens that could be sent to the colony, (1863, 131,) and by another from M. Hardy, the director of the Garden of Acclimatization of Algiers, who also announced his readiness to receive any (1863, 226). One lot sent in 1863 died on the way from Cairo to Algeria, (1863, 627); a second, sent in 1864, were more fortunate, as eleven were received (on October 31) by M. Hardy from M. Perrot de Chamarelle of Mauritius; these were placed in pendant vases, in which the water was often renewed, and the fishes were fed with flies (1864, 697, 701); most of them, however, died before the 19th of May, 1875, (1865, 358,) and the "depôt" (1865, 194) was thus exhausted. The same want of success that attended the attempts at introduction in the other countries awaited those made for Algeria.

AUSTRALIA.

Frequent attempts have also been made to introduce the gourami into Australia, especially the colony of Victoria. These were continued

from 1859 to at least 1864, (see Bulletin de la Société Impériale Zoologique d'Acclimatation, 1860, 98, 432; 1863, 153; 1864, 217, 305, 380; 1865, xxxvi,) but none were attended with eventual success.

CAPE OF GOOD HOPE.

Efforts appear to have been also made to introduce the species into the waters of the Cape Colony, (*op. cit.*, 1865, xxxvi,) but no documents are at present available giving detailed information.

EGYPT.

As already indicated, Egypt is on the highway from Mauritius to France; and, having a far more favorable climate, it was proposed to acclimatize them in that country, and thence introduce them into France. Koenig-Bey, the secretary to the Khedive, signified the desire of his government to be instrumental in such a work, (1864, 288, 314,) and agreed to work on shares with the society, keeping one-half and promising to send the other when the weather became favorable (1864, 696). Specimens were accordingly sent from Réunion by Messrs. Berg and Manés to the Egyptian functionary, (1864, 539, 696,) but were all lost on the way (1864, 539; 1865, 356); measures, however, were taken by the committee of the Acclimatization Society at Mauritius to send a consignment of fishes by every mail-steamer till success had crowned their efforts (1864, 539). Although partial success seems to have attended the endeavors to introduce them,* it seems to have been ephemeral; at least, no accessible data give any positive information respecting essential success (1866, 598; 1869, 242).

The recommendation has been made by the eminent ichthyologist, Dr. Günther, to attempt the introduction of the gourami (as well as the European cat-fish and the Australian *Oligorus*) into England, (Rep. Acclimatization Society of London; Bulletins de la Société d'Acclimatation de Paris, 1861, 98,) and others, too, have been sanguine in the belief that the acclimatization could be effected in England as well as in Germany; but the attempt has never been made, and we may certainly be easily convinced that if the climate of Marseilles and Southern France is too cold to enable them to survive through the year, more northern and colder countries would be still more incompetent to harbor them.

CONCLUSIONS.

Referring to the first part of this article on the gourami for information respecting the climate of the countries in which it thrives, and for the results of repeated experience of the limit of low temperature which it can withstand, and availing ourselves of the experience of the French, we must be convinced that the fish cannot be acclimatized, at least directly,

* "Pres. de S. A. Halim, Pacha au Caire, chez lequel on m'a assuré que ces poissons étaient acclimatés," 1866, 598.

in any country where at any time the temperature descends nearly to the freezing-point. What subtle influences have prevented propagation in the West Indies are unknown; the climate, so far as can be judged from thermometrical indications, can scarcely be an obstacle, and the cause of failure will probably be found in some unknown conditions. Of course, the experience in the case of the countries where attempts to acclimatize have been made equally teaches us that there is no hope for success in attempts to introduce it directly into any of the United States north of Florida or Lower California. And yet it is not utterly impossible that, starting from a tropical country, individuals might gradually be introduced northward; and while many would succomb to the cooler climate, (which, perhaps, would only be too cool once in a cycle of years,) a few would survive, and the descendants of such—themselves weeded out little by little—eventually leave a stronger race, which might in time be domiciliated in temperate climates. It may be, indeed, that (as in very many species of animals) there is already a difference in the susceptibility to cold of the several races of the gourami now acclimated in different countries, and that, in an Indian race, we have a more hardy form; such, at least, would seem to be the case if the fish referred to by M. Turrel was really the gourami; and, if it is so, that race would be the most suitable to experiment with. It must be remembered, however, that even M. Turrel's fishes were not claimed to have been subjected to a temperature lower than 39° Fahrenheit; and consequently the results of his experience (admitting that the fishes were gouramis) do not militate against the inferences here enunciated. None of the present generation could reasonably effect acclimatization of the species in northern waters; but, if any individual has no regard for a return for money expended, enthusiasm might be gratified by commencing with importation of specimens into our southern waters.

For the benefit of such, we refer to the articles teaching how to transport them,* and close with briefs of their instructions, and extracts from them by M. Coste.

C—RULES FOR TRANSPORTATION AND INTRODUCTION.

As to the introduction, it would, probably, be more readily effected by the transportation of nests with the ova than that by the fishes themselves; and such a course would, at least, require less care and attention, and would have the additional advantage of furnishing so many more individuals to select from. If, for any reasons, it is preferred to experiment with the young, the smallest should be chosen, and they should be placed in wooden or earthen ware vessels: the latter would be preferable, and those having a capacity of from ten to fifteen gallons would, perhaps, be best; but tubs or casks when perfectly clean

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* COSTE. *Instruction pour le transport des gouramis.* <Bull. Soc. Imp. Zool. d'Acclim., 1865, pp. 76–80.

DABRY (P. Thiersant). *Note sur le transport des gouramis.* <*Op. cit.*, 1868, pp. 591–592.

may be used. The receptacle, whatever it may be, should be suspended, in order to avoid the disturbance of its contents by the incessant rolling of the vessel; such motion being prejudicial to the welfare of the fishes. The fishes should also be fed, and a supply of suitable plants should therefore accompany them. We append a translation of the specific instructions of M. Coste, from whom, indeed, have been derived the hints above offered.

"1. Very young fishes should be selected.

"2. These fishes should be distributed among several receptacles.

"3. Care should be taken not to crowd too many together in one receptacle.

"4. The water should be renewed partially or entirely whenever it becomes necessary.

"5. It should also be aerated from time to time.

"6. The fishes should be fed whenever they shall seem to require it.

"7. The remains from the food which has been given to the fishes should be carefully taken up from the bottom of the receptacle, and removed within eight hours after feeding; the dejections and other impurities which would injure the water should be removed.

"8. Finally, the several receptacles should be kept in different places and under various conditions."

XXX.—NOTES ON THE GRAYLING OF NORTH AMERICA.

By James W. Milner.

The grayling has recently attracted a great deal of attention in the United States. The discovery, in accessible localities, of a fish of great beauty and fine game qualities, that hitherto was regarded as peculiar to the Arctic rivers of British America and to the Old World, gave it at once great prominence in the estimation of fish-culturists and anglers. These qualities are to be regarded as its special claim to attention rather than any likelihood that it is to become an extensive food-resource. As the latter purpose has been the only one so far recognized by the United States Commission, the propagation of this species is not likely to receive its attention. Yet, in view of the fact that the sport of angling is so generally popular, and that the presence of the game-fishes in the streams and rivers of a region are appreciated as no minor attraction, the possession of this beautiful fish is of sufficient consequence to deserve consideration under the State appropriations.*

A species inhabiting the headwaters of the Missouri River was observed in 1860 by Surgeon J. F. Head, U. S. A. In his correspondence, he called the attention of other naturalists to the fact, and asserted the tributaries of the Missouri west of Fort Benton to be its habitat. Specimens have since been obtained from Willow Creek and the Gallatin Fork of the Missouri by the United States Geological Survey,† and, through application made by Surgeon J. F. Head, others have been obtained from George Scott Oldmixon, acting assistant surgeon U. S. A., from the vicinity of Camp Baker, Mont., and from Dr. Charles A. Hart, acting assistant surgeon U. S. A., stationed at Fort Shaw, Mont., from the Sun River, tributary of the Missouri. A writer to Forest and Stream has found them plentiful in a tributary of the Yellowstone River near the Crow Indian agency.

In the particular of its being found in restricted, isolated areas, its habits resemble what is said to characterize *Thymallus vulgaris* of Eng-

* Fred Mather has advanced the argument, in "Forest and Stream," from the fact that they do not eat each other, that "cannibalism" does not prevail among them, they are likely to prove superior to the trout in their ability to produce a large stock of fishes.

† Preliminary Report of the Geological Survey of Montana and Portions of the Adjacent Territories, being a fourth annual report of progress, by F. V. Hayden, United States geologist, 1871, p. 469.

land. The grayling of Central Europe seems to have a more general distribution.

A species of this genus, on the continent of North America, was first noticed by Sir John Richardson, in the narrative* of Sir John Franklin's first journey to the Arctic Regions, where it was described and figured as *Coregonus signifer*, or Back's grayling. In his *Fauna Boreali-Americana*, 1836, is a colored plate of this species, under the name of *Thymallus signifer* Richardson. In both these works, another species is also described, the lesser grayling; in the former work under the genus *Coregonus*, in the latter as *Thymallus thymalloides*. In the *Fauna Boreali-Americana*, he suggests that it may be the young of *T. signifer*.

Richardson says that the range of Back's grayling is north of parallel 62°, and between the Welcome and Mackenzie Rivers, tributaries of the Arctic Sea.

A specimen of a grayling was in the possession of Valenciennes about 1847 or 1848, supposed to have come from Lake Ontario, which he named *Thymalus ontariensis*. As there is no subsequent record of its coming into the hands of any naturalist from the waters of the region, it has been thought probable that the locality affixed to the specimen was erroneous. Letters to Forest and Stream from correspondents have asserted the existence of a grayling in the waters of Canada in a stream near Quebec, where it had the local name of "spearing," and in the Northeastern United States near Derby Line, Vt., and in a stream at the headwaters of the Penobscot River in Maine. It has also been claimed, with but little evidence advanced, to inhabit a region of Wisconsin, and the vicinity of Pointe aux Pins, Canada, at the head of Saint Mary's River of Lake Superior.

During the winter of 1864 and 1865, Prof. Edward D. Cope, of Philadelphia, examined a large collection of fishes belonging to educational institutions of the State of Michigan, and, among them, found specimens of a grayling from the waters of the State, which he believed to differ from any species previously described, and gave the name of *Thymallus tricolor*.

In 1871, while visiting the Traverse Bay region of Michigan, in connection with my duties as assistant in the United States Fish Commission, a trip was made to the Jordan River for the purpose of procuring specimens; but, although a good many were seen in the clear, cold waters, they could not be induced to take the hook during the day spent on the river. Arrangements were made for the collection of specimens, and two were soon after sent to me at the Chicago Academy of Sciences. They were lost, with the rest of the collections, in the great fire of that year.

In the winter of 1872–'73, Mr. D. H. Fitzhugh, of Bay City, Michigan,

* Narrative of a Journey to the Shores of the Polar Sea in the years 1819, '20, '21, '22. By John Franklin, Capt. R. N., F. R. S. With an appendix on various subjects, including science and natural history. 4to. London, 1823. p. 711.

sent specimens to Mr. Charles Hallock, of New York, who placed them on exhibition at the restaurant of Mr. John Sutherland. Some of these, Mr. Sutherland transmitted to Professor Agassiz, and the receipt was acknowledged in a letter published in the New York Times. Subsequently, at the request of Mr. Hallock, specimens were sent, by Mr. Fitzhugh, to the National Museum at Washington, where they were received on the 19th of February of 1873.

Mr. Hallock makes reference in his book, the Fishing Tourist, and in the first number of his paper,* to the habits of the fish. In subsequent numbers, he published short notes from Mr. Fitzhugh, and in the paper of October 2 appeared a quite full account of its habits and localities from notes received from Mr. Fitzhugh and other correspondents. Since that time, the references to the species have been numerous in different journals.

In September, 1873, while engaged in investigations on Lake Huron, I made a trip with Mr. Fitzhugh to the Ausable River, for the purpose of obtaining specimens of the grayling, a knowledge of its habits, and the facilities for obtaining spawn in the proper season.

The experience of the two days on the river proved them to be free, strong biters, eagerly taking the fly, and with all the gaminess in resisting the effort to take them from the water with a hook, that is the special quality demanded by the anglers. They were decided to be quite equal to the brook-trout on the table; and for grace of form and beauty of color on the body and the great dorsal fin that is the peculiar mark of the genus, they surpassed all of the so-termed game-fishes. One hundred and forty-three were taken with two rods in the portion of two days occupied on the river.

Like that of the brook-trout, their natural food consists of the insects that fall or light upon the surface of the stream. Their stomachs were found to contain broken and partially-digested specimens of *Coleoptera*, *Neuroptera*, as well as the larvæ of species of the dragon-flies. There were also found in their stomachs the leaves of the white cedar, (*Thuja occidentalis*,) which drop continually on the surface of the stream, and are probably taken because the fish in their quick darts to the surface mistake them for insects falling upon the water. It is not at all probable that they select them as food.

The upper tributaries of the Muskegon and Manistee Rivers, the Boardman River and the Jordan River, emptying through Pine Lake, all tributary to Lake Michigan, the Ausable, the Rifle, the Marquette, and the Au Grès, all tributary to Lake Huron, are the streams in which the grayling have thus far been found. The only character that these waters have, differing from adjacent streams, is their exceeding coldness. Of the Jordan and Ausable Rivers only, I can speak from personal observation; but inquiry from those who have visited the portion of the other rivers inhabited by the grayling elicited similar observation of temperature in

* Forest and Stream, August 14, 1873, p. 13.

the waters. In the two rivers referred to, the temperature was nearly as low as the ordinary temperature of the springs of the region; the result probably of the very numerous springs along the banks and in the beds of the rivers. The temperature of the Ausable during the two days we were in the region, late in September, varied from 45° in the morning to 49°.3 in the evening. The Jordan River, visited in August, 1871, though not tested with a thermometer, was observed to be much colder than the waters of Pine Lake and River, into which it flows.

Mr. Fitzhugh says, of the Ausable, "The south branch of the Ausable is fed by a swampy lake at its source, and there are no grayling in it until you get nearly to its mouth, where it receives large springs, and the water becomes pure and cold."

If this low temperature be the controlling influence in the distribution of the species, there will be a considerably more limited area suitable for its propagation than for that of the brook-trout.

The *Thymalli* of Europe are spring-spawners. Heckel and Kner say of *T. vulgaris* of Central Europe* that it spawns at the breaking-up of the ice in spring usually in March, and the young brood come out in June. They, like the trout, excavate a hole in the gravel, in which they deposit the eggs, and according to these authors cover them over with gravel after the male has impregnated them. They are said to grow very rapidly, attaining a mature size in two years.

Siebold says of the grayling of this region † that the spawning-season begins in March and may last over into April. He says that, in spawning fishes, the nervous activity of the skin greatly increases, and the under surface of the scale becomes adherent to the skin throughout its length; probably a similar process to that observed in the California salmon by Livingston Stone during the spawning season, where the scales became imbedded in the epidermal sheathings.‡

Pallas says, of the species of Eastern Siberia and Kamtchatka, that it deposits the spawn about the time the ice is breaking up in the rivers. The Indians informed Sir John Richardson that *T. signifer* spawned in the spring months.

All of the species whose habits have been observed are spring-spawners.

In this particular, the species in the United States are similar.

This apparent anomaly in the habits of the salmon-family is peculiar to the *Salmo hucho* of Europe and the *Thymalli*. It is probably to be considered rather as a habit of late spawning, when compared with that of the other species, than as earlier.

The spawning time of the different species varies considerably as to

* Die Süsswasserfische der östreichischen Monarchie bearbeitet von Jacob Heckel und Dr. Rudolf Kner, Leipzig, Verlag von Wilhelm Engelmann, 1858. p. 245.

† Die Süsswasserfische von Mittel-Europa, bearbeitet von C. Th. E. v. Siebold, Professor der Zoologie und vergleichenden Anatomie in München. Mit 64 Holzschnitten und 2 farbigen Tafeln. Leipzig, Verlag von Wilhelm Engelmann, 1863. p. 270.

‡ See pages 182, 190, in Mr. Stone's article.

the time of year.* The Sacramento salmon (*Salmo quinnat?*) spawns from July until September and even October; the siscowet of Lake Superior (*Salmo siscowet*) in August and September. This also seems to be the season for the peculiar species (*S. Kennerleyi*) of the Pacific coast; the *S. oquassa*, similar in habit to the chars of Europe, has a very well defined season, between about October 10 and the middle of November. The salmon-trout (*S. namaycush*) also spawns in October, while the speckled trout (*S. fontinalis*) begins about this time and extends its season in some localities well into the winter. In November, the white-fish of the great lakes spawns; and, in the latter part of the month and in December, the lake-herring (*Argyrosomus clupeiformis*) in the vicinity of Sandusky, Ohio, on Lake Erie, was found to begin emission of spawn late in November, and continue it into December. The brook-trout of the Pacific slope (*S. iridea*) is said to begin spawning after Christmas; the *S. umbla* of Europe spawns in January and February; a species, *S. scouleri*, of the Pacific coast, is found far up the brooks in January, February, and March; the *S. hucho* and the *Thymalli* spawn in March and April. The species of the family not here referred to spawn contemporaneously with some one of those mentioned. As the reduction of the water to a certain condition of coolness seems to have relation to the spawning-season of the larger portion of the species, rather than an increase of temperature, it would seem to be more correct to speak of those spawning in late summer as the earlier spawners, and those in the spring as the later spawners.

The *Thymallus tricolor*, though observed only during one season, evidently spawns in the month of April. A letter from D. H. Fitzhugh, of Bay City, who has been identified so much with the efforts to attain a knowledge of the habits of the species, says that "April is undoubtedly the spawning-season, as Fred Mather and I were there on the 1st of April and found no ripe fish; Seth Green and I reached there May 1, and found all spawned out."

The period between the deposition of the eggs and the hatching in the English species, according to Frank Buckland, is fourteen days. Heckel and Kner state that the eggs are deposited in March and April, and the young fish appear in June; though this statement very likely refers to the time when the young fish first attract attention.

The only experience in grayling-hatching thus far in the United States is that of a few eggs procured by Seth Green from the bed of the Ausable River, and placed under the care of A. S. Collins, in the troughs at Caledonia Springs near Rochester, N. Y.†

* There is evidence with relation to certain species of fishes that the season is earlier in a southern warmer latitude than farther north.

† Mr. Collins, in Forest and Stream, publishes notes of his experience as follows: May 5, eggs arrived from Michigan; 8, first egg hatched; all eggs hatched out; 12, first fish began to rise and eat; 15, all swimming; the sac lasts about six days; the eggs are nearly as large as trout-eggs, but of less specific gravity; the fry resemble the young of the white-fish, (*Coregonus albus.*)

In the letter quoted previously from D. H. Fitzhugh it is stated: "I do not know any fish-culturists who have grayling except Seth Green and Fred Mather, who obtained them last spring. Mr. Green collected about one hundred eggs in the Ausable early in May, and informs me he hatched nearly all at Caledonia, and that the fry are thriving. George H. Jerome, one of our commissioners, had some on exhibition at the Michigan State fair. I do not know how many are in his possession."

Fred Mather, in a letter to Forest and Stream, quotes the statement from a letter from A. S. Collins, in whose hatching-house at Caledonia the grayling eggs were cared for, that "the young fishes were larger at six months old than the brook-trout at the same age."

This is a like fact with that stated by Heckel and Kner with reference to the grayling of Central Europe, that they grew very rapidly, and attained mature size when two years old.

The average size of the grayling in the Ausable River is not more than ten or eleven inches in length. It rarely attains the length of sixteen inches, and the largest recorded weighed less than two pounds; the average weight is not more than a half-pound.

The Old World species have attracted attention from a very early period; the impression that the fish possessed the odor of thyme suggesting the name of *θύμαλλος* to the Greeks.*

Linnæus called the grayling of Europe and Siberia *Salmo thymalus*. Artedi placed it as No. 3 of his genus *Coregonus*. The names *Salmo thymallus and Coregonus thymallus* were applied to all species known until Richardson described a species from Northern British America, collected by Lieutenant Back during Sir John Franklin's first Arctic journey, as *Coregonus signifer*; stating that the specific name "standard-bearer" applied to the character of the great dorsal fin. At the same time, a supposed second species was described, which he called *Coregonus thymalloides*, and which, in the *Fauna Boreali-Americana*, published later, he suggests to be the young of *T. signifer*, and, at the same time, changes the generic name to *Thymallus*.

After this, additional names were made, supposed to represent species of the Old World, until the list was increased to the number of ten. Nilsson gave the name of *Thymallus vulgaris* to a grayling found in Norway and in Lapland. Agassiz named the grayling of Central Europe *Thymallus vexillifer;* a *T. thymallus* from Denmark was named by Kroyer; Valenciennes gave the names of *Thymalus gymnothorax* to one from Berlin, Germany; *T. gymnogaster* to one from the Neva near St. Petersburg; *T. Æliana* to one from Lake Geneva; *T. Pallasii* to one from Russia; *T. ontariensis* to one supposed to have come from the vicinity of Lake

* The grayling, in Northern Italy, is still said to have the common name of *Temolo*. In Germany, it has the name of *Aesch*, referring to its gray or ash-colored tint, a derivation similar to that of its English name grayling, which is said to have been first used by Willughby, who published a history of fishes in 1686.

Ontario, North America; *T. Mertensii* described from a drawing of a grayling from Kamtchatka. In 1869, B. N. Dybowsky named a graying, from Southern Siberia, *T. Grubii.*

Siebold, in his work on the fresh-water fishes of Central Europe, under *Thymallus vulgaris*, includes, *T. vexillifer*, *T. thymallus*, and *T. gymnothorax* of all authors, and, in a foot-note, is inclined to refer *T. gymnogaster* to the same species.

Günther believes that *Thymallus vexillifer*, *T. thymallus*, and *T. gymnothorax* as referred to by all authors are one and the same species with the first-named *T. vulgaris* of Nilsson. *T. ontariensis* and *T. Mertensii* he casts aside as invaluable; the latter probably because it was described from a drawing more or less inaccurate of the species it was intended to represent.

The genus has a wide range in the northern latitudes from Lapland through England and Northern and Central Europe to Italy; throughout Siberia and Kamtchatka; in the northern fresh waters of Alaska and British America; and in at least two localities in the United States, that of a portion of Michigan and some of the upper tributaries of the Missouri River.

A very fine specimen of the grayling from the region where Richardson procured his specimens is in the possession of the National Museum collection, which corresponds quite nearly with his original description.

It measures, in extreme length, seventeen and a half inches; and the dorsal fin exceeds in dimensions everything that has been described or figured, except the original figure * of Richardson's type of the species *T. signifer*, in the appendix to the narrative of Sir John Franklin's first journey to the Arctic Sea.

A comparison of the proportions of the specimen in hand with those which have been compiled from the figure † published in the *Fauna Boreali-Americana* of a specimen from Great Bear Lake affords very close similarity of characters. The most marked variations in the two series of measurements are the greater height of body in the drawing and slightly greater length in the maxillary. The description and figure of Richardson make the number of scales in the lateral line to be 87, while in the Fort Simpson specimen there are 98.

In the description of *T. signifer*, it is stated that there are no teeth upon the tongue, while they are present in the specimen.

In the description, especially in the measurement of the head on its lateral and superior surfaces, and the length of the snout, the differences are much more marked. But these differences are of such extent when com-

* Richardson states that this figure is not correct.

† Richardson says of this figure, "I much regret that that specimen, [alluding to the type specimen of the species obtained from Winter Lake,] having gone to decay, I cannot compare it with the one brought by the last expedition from Great Bear Lake, of which the figure in the present work is an exact representation, drawn on a scale of half the natural size."

pared with a large number of specimens of four species from seven widely-separated localities in North America and Europe, that an error is naturally supposed. To support this suspicion, the figure which is referred to as "an exact representation" does not at all corroborate the proportions given in the description, but does approach the proportions for like measurements in other species of the genus.

To illustrate this statement, the length of the head compared to the length of the fish, excluding the caudal in twenty individuals of different species, showed the different proportions of 19¼ hundredths to 22½. Calculated from the measurements given in Richardson's description, the length of head is only 15½ hundredths, while in the figure it is found to be 17. The distance from snout to edge of orbit, compared to the length of head in seventeen specimens, had a range of from 22 hundredths to 26⅔, while in the description it is 14½ hundredths, and in the drawing 26.

It has seemed to me that these discrepancies invalidate to a great extent the value of the differences between Richardson's specimens as described in his later work and the specimen from Fort Simpson.

The geographical region from which the type of *T. signifer* was obtained, from which the original of the figure and description in *Fauna Boreali-Americana* came, as well as the specimen in the National Museum is the valley of the McKenzie River, from whose tributary waters all were taken.

After consideration of these facts, I have decided to determine the specimen before me to be a true *Thymallus signifer*, notwithstanding the points of difference from Richardson's description, before referred to, in the number of scales in the lateral line, and the presence or absence of teeth upon the tongue.

Three specimens are in the collection from the Yukon River of Alaska, which arrived in too bad condition to be of value. The heads afford some characters for comparison, and, in all particulars, correspond well with *T. signifer*.

The width of the head and of the operculum in two specimens of a grayling from Alaska—skins—labeled "St. Michael's, Norton Sound, H. M. Bannister"—but which, it is believed, were brought to that point from some stream at a distance—does not resemble *T. signifer*.

These have greater width in the interorbital area, and a much greater length in the operculum than in the other specimens from the far north as well as south; the proportions of these measurements to the length of the head exceeding the maximum in all of the other graylings examined, except in the first-mentioned character in one specimen of the Michigan species. In other particulars they correspond.

The bones of the head in the northern specimens are heavier and more compact. A foramen situated in the frontal suture in the graylings from Michigan and Montana was not found in the northern specimens.

The length of the maxillary is greater in the southern forms, and the distances from snout to dorsal and anal fins are greater.

The northern specimens differ from *T. tricolor* in having a maxillary of less length and less distance from the snout to the insertions of the dorsal and the ventrals, and smaller diameter of orbit. Teeth are present on the tongue.

Specimens of the Montana grayling, sent from tributaries of the Missouri by George Scott Oldmixon, acting assistant surgeon U. S. A., and by Professor Hayden, to the National Museum collection, have greater height of body than in the Michigan species. Of the latter, out of seven specimens measured, the maximum height was 22½ hundredths of the length, the minimum being .20; the mean height was .21 Out of six good specimens of the former, the maximum was .24¼ of the length, and the minimum was .23½, which was more than the greatest height found in the eastern specimens. This character was confirmed in the evident slenderness of all the individuals in a collection of seventy-five specimens from Ausable River, Michigan.

A comparison of measurements of least height of tail also evinced similar differences. The maximum in the six Montana specimens was 9 hundredths of the length, and the minimum was .08½; the average being .08¾. The average in the seven Ausable specimens was .07½; the maximum being .08¼, and the minimum only .07.

The width of the head affords another character of similar import. In six specimens examined, the width of the head is much greater than in any of the specimens from Michigan. The maximum shown by the callipers was .48½ of the length of the head, and the minimum .45½; while out of seven Michigan specimens, the greatest was .44¾, and the least .41¾. The width of the interorbital areas corresponded with the differences of the thickness of the head.

The maximum and average lengths of the maxillary and the mandible, and also of the distance from tip of snout to orbit, are greater in the Michigan species; though individuals from each locality were found in which they formed an equal proportion of the length of the head.

The diameter of orbit is greater in the Michigan fish. The maximum in seven fishes is .31¼ of the length of the head, while the minimum is .28¾. In six Montana specimens, the maximum is .28¾, and the minimum is .24.

In twenty-five or thirty specimens of the Michigan species examined, no matured specimen was found that had the least vestige of a tooth upon the tongue. Three young individuals out of seven or eight were found to have teeth in this position, from one to three very minute ones being found present.

Out of nine specimens from Montana, partly grown and matured, every one had a distinct patch of teeth upon the tongue, from seven to ten in number.

The length of the head from snout to edge of opercle, and from snout

to edge of occiput, the width of operculum, the distances from snout to the insertion of the fins, excepting the dorsal, the lengths of the bases of the fins, the number of rays, the number of branchiostegals, the number of scales in the lateral line, and the number of transverse rows of scales above and below the lateral line, and the number of cæcal appendages, agree quite closely in a comparison of these species.

From a comparison of notes furnished by Assistant Surgeon Oldmixon, made from a fresh specimen in Montana, with my own notes, made on the banks of the Ausable River, from fresh specimens from its waters, the coloration is found to differ somewhat.

Dr. Oldmixon says that the "red spots" upon the dorsal are "encircled by a thin border of bright emerald-green." The presence of green upon the ventrals, and the fact that the caudal is "plain" as to color, are all points of difference in examining the coloration.

These variations of characters found to exist in the graylings of different regions of North America warrant the recognition of three species at least, the descriptions of which are given in the following pages.

The probability of the existence of a grayling in Canada and the Northeastern United States, already referred to, involves the possibility that Valenciennes' *T. ontariensis* may again be found, which will at least be likely to revise the nomenclature of the species.

THYMALLUS Cuvier.

Fusiform. Mouth small, with small, needle-like teeth of uniform size; none on the pterygoid bones. Dorsal fin very largely developed; rays of anterior portion of fin simple; posterior rays bifurcated, and often unusually prolonged. Thoracic region with minute scales; sometimes naked.

THYMALLUS SIGNIFER Richardson.

Coregonus signifer Richardson, Nar. of Jour. to Polar Sea, Franklin, p. 711, pl. 26.

Coregonus thymalloides Rich., *op. cit.*, p. 714, [young.]

Salmo (*Thymallus*) *signifer* Rich., Back's grayling, Faun. Bor. Amer., part iii, p. 190, pl. 88.

Salmo (*Thymallus*) *thymalloides* Rich., lesser grayling, *op. cit.*, p. 194.

Thymalus signifer Cuv. and Val., vol. xxi, p. 450; Günth. Cat. Fishes, Brit. Mus., vi, p 202.

Thymalis Pallasii, Dall, Alaska and its Resources, p. 579; Rept. Dept. Agric., [U. S.,] 1870, p.

The greatest height of body is more than the length of the head and much less than the base of the dorsal. The length of the snout is equal to the diameter of the orbit, and less than the interorbital area; the diameter of the orbit is equal to the length of the operculum. The anterior ray of the dorsal fin is in front of a point midway between the pectorals and the ventrals. The last ray of the anal fin is posterior to the insertion of the adipose fin.

The height is $21\frac{3}{4}$ hundredths of the length. The distance from the

snout to the dorsal fin is .31. The distance from the snout to the anal fin is .74. The distance from the snout to the origin of the ventrals is .47. The length* of the caudal peduncle is .16.

The length of the head is .19½ of the length without caudal; the distance from snout to nape is .13½ of the same. The width of the head is .44¾ of the length of the head; the width of the interorbital area is .26⅔; the length of the maxillary is .30¾; the length of the snout is .24½; the length of the operculum is .25¼; the diameter of the orbit is .25.

Br., 9; D., 24; A., 3–11; C., 8–18–7; P., 15; V., 10; scales on lateral line, 98; transverse rows of scales above lateral line, 8; below lateral line, 11–4.

The distance from the snout to the dorsal is less than in *T. tricolor* and the adipose fin is more slender. The maxillary is shorter than in *T. tricolor* or *T. montanus*†. The thickness of the head is less than in *T. montanus*, and the mandible is longer.

Teeth are present upon the premaxillaries, maxillaries, vomer, palatines, mandible, pharyngeals, and tongue.

There is a small naked space on the branchial isthmus.

Length, 17.5 inches.

National Museum, No. 3333. Locality, Fort Simpson, British America. Collector, Bernard R. Ross.

The two skins labeled "St. Michael's, Norton Sound, Alaska," differ considerably from the species just described in the greater width of head and interorbital area, and markedly in the width of the operculum. In all other characters, they are apparently similar. Additional specimens are needed to determine its relation to this species.

THYMALLUS TRICOLOR Cope.‡

Thymallus tricolor Cope, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 80; Günther, Cat. British Museum, vol. 6, p. 201; Cope, Prelim. Rep. U. S. Geol. Surv. Montana and Portions of Adj. Terr., p. 469.§

Body elongate, subcompressed, highest at the anterior portion of dorsal fin. The greatest height of body equal to the length of head. The

* Measured from a point vertical to the last ray of the anal fin.

† Described on page 741.

‡ The prominent characters of *T. vulgaris* are the straight profile of the head; the muzzle is prolonged and flattened, the lower jaw shutting easily within the premaxillaries; the maxillary is short and wide, reaching but little beyond the edge of the eye; the mandible is dilated at its anterior end; the orbital opening is acute forward; the dorsal fin is smaller; the scales are arranged in parallel linear rows; the striæ are coarser; on the anterior of the thoracic region between the pectoral fins and for nearly half the distance to the insertion of the ventrals, the skin is naked. The scales in the vicinity of this region are very minute, and increase in size rather rapidly upon the sides and toward the ventral fins; the scales of the lateral line are larger; and the appendages to to the ventrals are longer.

§ Popular descriptions have been given in the following journals: Mather, (quoted in editor's article,) Forest and Stream, (N. Y.,) vol. ii, June 4, 1874, p. 265, (with plate;) Mather, (quoted in editor's article,) American Agriculturist, (N. Y.,) vol. xxxiii, p. 333, Sept., 1874, (with plate;) Mather, Live Stock Journal, (Buffalo, N. Y.,) vol. v, p. 214, July, 1874, (with plate.)

length of the snout is about equal to the interorbital area. The diameter of the orbit is greater than the length of the operculum. The origin of the dorsal fin is vertical to a point midway between the insertions of the pectorals and the ventrals. The last ray of the anal fin is opposite to the anterior insertion of the adipose fin.

The greatest height is .21½ of the length without the caudal; the greatest width of body is .09; the least height of tail is .07¾; the length of the caudal peduncle,* .16; the distance from the snout to the dorsal fin is .35½; the length of the base of dorsal is .23; the distance from the snout to the anal fin is .76; the distance from snout to ventrals is .51; the length of the median rays of caudal is .07¼; the length of the external rays of the same is .20.

Head .21½ of the length without caudal; the distance from the snout to the nape is .15¼; the width of the head is .44½ of the length of the head; the width of the interorbital area is .24½ of the same; the length of the maxillary is .33¾; the length of the mandible is .51; the length of the snout is .25; the length of the operculum is .25½; the diameter of the orbit is .27¾.

Br., 9; D., 24; A., 3–11; C., 8–19–7; P., 16; V., 10; scales in lateral line, 92; transverse rows of scales above lateral line, 8; below lateral line 11–4; cæcal appendages, 18.

The height of the body is less than in *T. montanus;* the length of the head is greater than in *T. signifer;* the distance from the snout to the dorsal fin is greater than in *T. montanus* or in *T. signifer;* the furcation of caudal is slightly more; and the adipose fin is larger.

The head is more compressed than in the two species mentioned; the maxillary is longer; and the diameter of orbit is greater.

There are teeth upon the premaxillaries, maxillaries, vomer, palatines, mandibles, and pharyngeals. In mature specimens, no teeth are found upon the tongue; and but rarely from one to three minute teeth are found in this position in young specimens.

The scales have less of the regular linear arrangement than is found in *T. vulgaris* and *T. montanus.*

Color: purplish gray, (in young specimens approaching silvery white on sides and belly;) darkest on back, and verging toward white on belly, with faint tendency to bluish tint. The premaxillary and tip of mandible have a bluish tinge; the same color shows strongly on the white of the inside of the lower jaw. The opercula have bronze-yellow, purplish, and dusky tints. The sides from the opercula to the middle of body have small, black, irregular spots. In young specimens, the spots continue much farther toward the tail.

The pectoral fins are light brown, with a yellowish cast. The outer ray is dark brown; the inner and inferior margin of the fin pale slate.

The ventral fin has the distal half of the outer ray black; the proximal portion is lighter; diagonal lines of rose-color extend across the mem-

* Measured from the vertical of the posterior edge of the adipose fin to the caudal.

brane and rays; the first line begins in the middle of the anterior ray and extends diagonally across the membrane and the second ray; the second line has its origin at the proximal end of the first ray, and, extends across membranes and rays, to the outer end of the fourth ray; the third line begins near the body on the fifth ray, and extends along the intervening membrane between the fifth and sixth rays; the fourth line, beginning some distance from the body, upon the membrane between the seventh and eighth rays, extends in a broken line anteriorly, and terminates upon the membrane between the sixth and seventh rays, and upon the seventh ray. The lines sometime have flecks of yellow upon them. The rest of the fin is dusky, the first rays and membranes being darker than the others.

The dorsal along its insertion has a black line; next, one of faint rose-hue; then there is a blackish one; again one of rose-hue; then blackish again; then there is one of rose-hue, beginning at the sixth ray and extending to the middle of the fin, and continuing out as a row of spots in a dark ground; then there is a row of spots of dusky-green tint; then a row of minute spots of rose; then a broad dusky area. The middle portion of the margin of the fin is tipped with rose.

The anal and adipose fins are dusky with a faint bluish cast.

The central rays of caudal are purplish pink; the other rays are dusky brown. The outer margin of the caudal is tipped with lines of colors like a faint spectrum.

A very small naked space is found on the branchial isthmus.

Length, 11.83 inches.

National Museum, No. 11099. Locality, Ausable River, Michigan. Collector, D. H. Fitzhugh, jr.

THYMALLUS MONTANUS, *sp. nov.*

Form much less elongate than in *T. tricolor.* The greatest height of the body is more than the length of the head, and nearly equal to the base of the dorsal. The length of the snout is less than the width of the interorbital area. The diameter of the orbit equals the width of the operculum. The origin of the dorsal fin is anterior to a point midway between the pectorals and the ventrals.

The height is .23½ of the length without the caudal; the greatest width of the body is .10½; the least height of tail is .09; the length of the caudal peduncle is .15½; the distance from the snout to the dorsal fin is .33½; the length of the base of the dorsal is .25; the distance from the snout to the anal fin is .75; the distance from the snout to the ventrals is .45⅓; the length of the median rays of the caudal is .07; the length of the external rays is .16¼.

The head is .21½ of the length without the caudal; the distance from the snout to the nape is .15½; the width of the head is .45⅓ of the length of the head; the width of the interorbital area is .26¾; the length of the maxillary is .32¾; the length of the mandible is .47⅓; the length of the

snout is .24¾; the length of the operculum is .24½; the diameter of the orbit is .25¾.

Br., 9; D., 22; A., 3-11; C., 6-19-7; P., 16; V., 10; scales in lateral line, 95; transverse rows of scales above lateral line, 8; below lateral line, 10-5; cæcal appendages, 18.

The height of the body is greater than in the other American species; the length of the head is greater than that of *T. signifer*. The distance from the snout to the dorsal is greater than in the latter species and slightly less than in *T. tricolor*. The furcation of the caudal is less than in *T. tricolor;* the adipose fin is more slender in form; the head is thicker; the length of the maxillary is less, as is also the diameter of the orbit.

Teeth are present on the premaxillaries, maxillaries, vomer, palatines, mandible, and pharyngeals, and a group of seven or eight are found upon the tongue.

The scales to some extent assume the linear arrangement characterizing *T. vulgaris* and not discernible in *T. tricolor*. The scales in the thoracic region are slightly smaller than in the latter species. A small naked space is to be seen on the branchial isthmus.

Length, 11.75 inches.

National Museum, No. 13090. Locality, Camp Baker, tributary of the Missouri River, Montana Territory. Collector, J. Scott Oldmixon, acting assistant surgeon, United States Army.

MATERIAL.

Thymallus vulgaris Nilss.—One specimen, 10 inches long, presented by H. Denny, Leeds, England; two specimens, 12¾ inches in length, from Rudolph Hessel, Offenberg, Germany.

Thymallus signifer Rich.—One specimen,—carefully-stuffed skin, in excellent condition,—17½ inches long, from B. R. Ross, Hudson Bay Company's factor, Fort Simpson, B. A.; one specimen, 7½ inches long, in alcohol, from same locality and collector; three specimens, alcoholic, in bad condition, from Yukon River, Alaska, W. H. Dall; two specimens,—differing slightly from the others,—labeled "St. Michael's(?), Norton Sound, Alaska, H. M. Bannister."

Thymallus tricolor Cope.—Seventy-five specimens from Au Sable River, Michigan, from 6 to 14 inches in length; collected by D. H. Fitzhugh, jr., and James W. Milner.

Thymallus montanus, sp. nov.—Three specimens, collected for Smithsonian Institution, at solicitation of Surgeon J. F. Head, U. S. A., by Acting Assistant Surgeon George Scott Oldmixon, Camp Baker, Montana Territory; three specimens, (arrived in bad condition,) collected by C. A. Hart, acting assistant surgeon United States Army, at the request of Surgeon J. F. Head, from Fort Shaw, Montana Territory; three specimens, collected by Dr. F. V. Hayden, United States geologist, at Willow Creek, headwaters of Missouri River, Montana Territory.

APPENDIX G.

MISCELLANEOUS PAPERS.

XXXI.—TEMPERATURES IN THE GULF OF MEXICO.

[For the following article on the temperatures and depths of the Gulf of Mexico, with reference to the abode therein of shad and salmon, I am indebted to Capt. C. P. Patterson, Superintendent of the United States Coast-Survey. It is probable that the earlier observations do not give a sufficiently low indication of the temperature; all indications prior to the introduction of the encased-bulb thermometers of Negretti and Miller being liable to this error.—S. F. BAIRD.]

United States Coast-Survey report for 1854, *p.* 72.—" Between latitude 28° to 26° 40′, and within 30′ of longitude of Pass à Loutre, (the latitude of the entrance of the pass being 29° 10′,) the temperature of the water at the surface was found to be from 77° to 78° Fahrenheit, the air being from 72° to 77°. At 30 fathoms, within the same limits, the temperature was about 77°, but the subsurface temperatures were very irregular. These observations were made on the 5th, 6th, and 7th of April, 1854. North of latitude 28° 40′, 1° east of Pass à Loutre, the temperatures at the surface were 70°, 69°, and 68° on the 8th and 9th of April, the air being 71° and 70°, and the temperature at 15 fathoms 70°.5 and 68°, showing, within forty nautical miles, a fall in the temperature of the surface and below of some 8° Fahrenheit. This remarkable change requires further investigation."—(From the Hydrographic Work of Lieutenant Sands relating to Deep-Sea Soundings and Temperatures.)

United States Coast-Survey report for 1855, *p.* 89.—" Late in December, while the temperature of the air was from 61° to 73°, surface temperatures in the Gulf were found as high as 77° Fahrenheit, and that at the depth of about 230 fathoms the lowest temperature measured was 50° Fahrenheit."—(Reported by Lieutenant-Commander Sands.) Several stations off the mouth of the Mississippi, at depths from 15 to 50 fathoms, as given on his sketch, make the surface and subsurface temperatures nearly the same, but some stations were warmer than others, varying from 68° to 78°.

United States Coast-Survey report for 1856, *p.* 75.—(From Commander Sands' work. He ran lines of soundings between Key West and the Mississippi Delta, &c.)—"The interesting results as to the deep-sea temperatures developed along this line are shown in the diagram of sketch No. 40. Between latitudes 27° 06′ and 28° north and longitudes 85° 20′ and 86° 39′ west, in the Gulf, at the depths of 421, 610, and 790 fathoms, temperatures as low as 35° and 36° Fahrenheit were reached in the month of April. The lowest temperature in winter belonging to this region is about 52°, at a depth of 230 fathoms."

United States Coast-Survey report for 1857, *p.* 102.—(From the work of Commander Sands on Deep-Sea Soundings between the Delta and Key West.)—"At the bottom, the temperature in the month of May was 38° Fahrenheit, the air being 78° and the surface-water 77½°."

United States Coast-Survey report for 1858, *p.* 89.—"The highest temperature observed at 50 fathoms was 78° Fahrenheit, and the lowest obtained 38°, at the depth of 802 fathoms, at the position 9, five miles from Havana."

"On the line from the mouth of the Mississippi to the Tortugas, Commander Sands found the temperature at the bottom, at the depth of 1,133 fathoms, to be 28° Fahrenheit. This position is in latitude 27° 16′ north, longitude 86° 57′ west."

Same volume, p. 106: "From the Southwest Pass of the Mississippi, Commander Sands, in the steamer Walker, carried a line for depths and temperatures across the Gulf in the direction of the Tortugas. The greatest depth found on the line (1,710 fathoms) was in a position nearly south of one in which a deep cast (1,511 fathoms) was made in the previous year. At the next station eastward, 2,000 fathoms of line were payed out without indicating bottom. This was in a position north of the passage between the western end of Cuba and Yucatan."

The temperatures were observed at the surface, at 50, and at 100 fathoms, and at the bottom, in 22 different positions, the lowest (34°) being obtained at a depth of 896 fathoms, about one hundred and twenty miles from the Delta. The surface temperature in the same position was 77°.

United States Coast-Survey report for 1859, *p.* 80.—The above results were verified by Lieutenant-Commander Huger, and something added to the data for the Gulf Stream between Cuba and Florida, where temperatures are found of 38° at a depth of 600 fathoms.

United States Coast-Survey report for 1860, *p.* 84.—Lieutenant Wilkinson, in returning from Mobile to Key West, "observed with the deep-sea thermometer and recorded the temperature found in the Gulf water to a depth of 200 fathoms. Besides the record of the air-thermometer and the register at the depth just stated, the temperature was noted in twenty-three positions, at the surface also, and at 10, 30, and 100 fathoms. In latitude 24° 05½′ north, longitude 82° 52′ west, (see sketch No. 27,) the temperature found at 190 fathoms was 38° by the Saxton thermometer, that of the surface being at the same time 83°."

In 1872, lines of soundings were run by Lieutenant-Commander J. A. Howell, from the records of which enough have been selected to afford some knowledge of the temperatures met with. The maximum and minimum temperatures were obtained with a deep-sea registering-thermometer.

Table of temperatures.

	Number of soundings.	Position.		Depth, in fathoms. (L=line; R=register.)	Temperatures.			
						Water.		
							Subsurface.	
		Latitude.	Longitude.		Air.	Surface.	Max.	Min.
		° ′	° ′		°	°	°	°
February 17, 1872:								
1 51 p.m.....	5	25 03 N...	82 0.9 W...	10¼ L...	68	69	72	68
3 5 p.m.....	10	25 03 N...	82 6.2 W...	10½ L...	69	69	67	68
4 19 p.m.....	15	25 03 N...	82 11.7 W...	12 L...	67	69	67	67
5 45 p.m.....	20	25 03 N...	82 17.8 W...	13 L...	66	69	67	67
7 19 p.m....	25	25 03 N...	82 23.6 W...	15 L...	67	69	69	68
8 37 p.m.....	30	25 03 N...	82 30.4 W...	16 L...	66	69	68	66
9 45 p.m.....	35	25 03 N...	82 36.6 W...	19 L...	67	68	68	66
10 56 p.m.....	40	25 03.1 N...	82 42.5 W...	22 L...	67	70	68	66
February 18, 1872:								
0 15 a.m.....	45	25 03.2 N...	82 49.2 W...	22½ L...	66	69	67	68
1 49 a.m....	50	25 03.2 N...	82 56 W...	25½ L...	67	69	69	65
3 3 a.m.....	55	25 03.3 N...	83 2.6 W...	27 L...	67	66	68	67
4 16 a.m.....	60	25 03.4 N...	83 8.8 W...	30 L...	67	70	67	66
6 13 a.m.....	65	25 03.5 N...	83 15.5 W...	33½ L...	66	69	67	63
7 24 a.m.....	70	25 03.6 N...	83 21.7 W...	34¾ L...	69	68	67	65
9 0 a.m.....	75	25 03.6 N ..	83 30 W...	36 L...	69	69	67	67
10 24 a.m.....	80	25 03.7 N...	83 36.5 W...	39 L...	73	70	70	68
11 50 a.m.....	85	25 03.9 N...	83 42.2 W ..	40 L...	74	70	70	68
1 21 p.m.....	90	25 03.9 N...	83 49 W...	46 L...	75	71	69	67
3 5 p.m.....	95	25 04 N...	83 55.1 W...	60 L...	73	70	68	64
4 41 p.m.....	100	25 02.8 N...	84 3 W...	78 R .	74	78	71	61
8 51 p.m.....	105	24 56.5 N...	84 14 W...	169 R...	76	78	74	55
9 40 p.m.....	106	24 55.1 N...	84 15.5 W...	183 R...	76	77	75	52
10 24 p.m.....	107	24 53.9 N...	84 17.1 W...	191 R...	77	77	80	47
11 17 p.m.....	108	24 52.5 N...	84 19 W...	335 R...	77	77	77	43
February 19, 1872:								
0 23 a.m.....	109	24 50 N...	84 22.3 W...	305 R...	77	78	77	43
1 43 a.m.....	110	24 47 N...	84 26.3 W...	350½ R...	75	78	77	43
7 28 a.m.....	111	24 44 N...	84 30 W...	472 R...	75	76	77	41
February 20, 1872:								
1 9 p.m.....	1	25 50 N...	84 33 W...	109 R...	70	78	73	62
2 7 p.m.....	2	25 50 N...	84 38 W...	109 R...	73	77	74	64
2 58 p.m.....	3	25 50 N...	84 43 W...	118 R...	72	77	73	64
3 56 p.m....	4	25 50 N...	84 48 W...	151½ R...	73	75	73	62
4 51 p.m.....	5	25 50 N...	84 52.3 W...	214¾ R...	72	75	75	54
5 54 p.m.....	6	25 51.5 N...	84 58.4 W...	340 R...	68	78	78	46
7 4 p.m.....	7	25 54 N...	85 1.8 W...	403 R...	69	76	71	42
8 30 p.m.....	8	25 57.5 N...	85 7.2 W...	960 R...	68	74	71	40
10 40 p.m.....	9	26 3 N...	85 6 W...	1,000 R...	69	74	75	40
April 20, 1872:								
0 35 a.m.....	61	27 7.5 N...	83 59 W...	42 L...	75	76	82	72
1 50 a.m.....	63	27 7.5 N...	84 5 W...	44 L...	76	76	92	73
3 7 a.m.....	65	27 7.5 N...	84 11 W ..	50 L...	74	77	89	74
5 44 a.m.....	68	27 7.5 N...	84 20.2 W...	70 L...	74	77	83	77
8 8 a.m.....	71	27 7.5 N...	84 29 W...	90 L...	75	77	84	73
10 50 a.m.....	73	27 8 N...	84 36.6 W...	100 L...	78	80	......	67
12 14 p.m.....	74	27 8 N...	84 43.9 W...	105 L...	78	80	80	66
1 30 p.m.....	75	27 8 N...	84 49.3 W...	134 R...	78	85	85	68
2 55 p.m.....	76	27 8 N...	84 55.4 W...	178 R...	78	79	84	65
4 15 p.m.....	77	27 8 N...	85 3.1 W...	370 R...	77	79	82	55
6 10 p.m.....	78	27 8 N...	85 8.9 W...	515 R...	77	78	85	53
7 54 p.m.....	79	27 8 N...	85 16.1 W...	815 R...	76	78	......	41
April 22, 1872:								
1 18 a.m.....	1	26 17.5 N...	85 20.5 W...	1,708 R...	76	80	88	40
7 10 a.m.....	2	26 17.5 N...	85 15.9 W...	1,224 R...	75	80	79	41
2 16 p.m.....	5	26 17.5 N...	85 15.9 W...	1,116 R...	83	84	77	46
3 59 p.m.....	6	26 17.5 N...	85 7.7 W...	1,821 R...	79	82	76	41
10 0 p.m.....	7	26 17.4 N...	84 53.2 W...	748 R...	77	81	80	41
April 23, 1872:								
0 25 a.m.....	8	26 17.4 N...	84 47.4 W...	403 R...	76	80	76	43
2 9 a.m.....	9	26 17.4 N...	84 42 W...	180 R...	77	80	72	57
3 26 a.m.....	10	26 17.4 N...	84 37 W...	133 R...	75	80	72	56
3 47 a.m.....	11	26 17.4 N...	....	132 R...	75	80	72	56
6 51 a.m.....	13	26 17.4 N...	84 31.4 W...	123 R...	73	80	72	57
9 0 a.m.....	15	26 17.3 N...	84 26.5 W...	113 R...	77	80	75	60
11 30 a.m.....	18	26 17.2 N...	84 19.1 W...	100 R...	79	81	80	57
12 57 p.m.....	20	26 17.2 N...	84 14 W...	93 R...	75	80	82	58
3 37 p.m.....	25	26 17 N...	84 2.5 W...	73 R...	75	78	73	61
6 49 p.m.....	30	26 17 N...	83 50 W...	61 R...	73	77	85	74
11 31 p.m.....	36	26 16.8 N...	83 35.6 W...	37.4 R...	74	78	72	67

Table of temperatures—Continued.

	Number of soundings.	Position.		Depth, in fathoms. (L=line; R=register.)	Temperatures.			
						Water.		
		Latitude.	Longitude.		Air.	Surface.	Subsurface.	
							Max.	Min.
		° ′	° ′		°	°	°	°
April 24, 1872:								
1 12 a. m.....	39	26 16.8 N...	83 28.1 W...	35 R...	77	78	76	65
3 59 a. m.....	44	26 16.6 N...	83 16.1 W...	30 R...	74	78	79	67
6 41 a. m.....	48	26 16.6 N...	83 6.2 W...	27 R...	73	79	75	49
9 29 a. m.....	53	26 16.5 N...	82 55 W...	21 R...	72	74	75	71
7 2 p. m.....	89	26 16 N...	82 21.9 W...	8 R...	71	78	85	83
April 27, 1872:								
5 22 a. m.....	1	25 2 N...	84 2.5 W...	83 R...	73	78	......	71
6 1 a. m.....	2	25 2 N...	84 5.5 W...	86 R...	73	78	78	64
7 24 a. m.....	3	25 2 N...	84 12.5 W...	169 R...	75	78	78	52
8 50 a. m.....	4	25 2 N...	84 17.6 W...	278 R...	77	78	80	46
10 19 a. m.....	5	25 2 N...	84 23.8 W...	868 R...	76	79	79	41
11 40 a. m.....	6	25 1.9 N...	84 28.8 W...	871 R...	76	81	73	39
3 2 p. m.....	7	25 1.8 N...	84 30 W...	1,446 R...	76	81	79	39
6 32 p. m.....	8	25 1.7 N...	84 36 W...	1,664 R...	75	81	77	41
May 13, 1872:								
8 5 a. m.....	7	24 30.6 N...	83 2.8 W...	15 L...	74	78	86	85
8 51 a. m.....	8	24 29.1 N...	83 5 W...	24 L...	76	78	85	84
10 15 a. m.....	10	24 25 N...	83 13.5 W...	63 L...	78	79	85	68
12 15 p. m.....	13	24 21.2 N...	83 21 W...	190 R...	80	78	82	53
3 38 p. m.....	16	24 16 N...	83 30 W...	380 R...	77	78	86	55
5 11 p. m.....	17	24 12.5 N...	83 36.2 W...	521 R...	75	78	91	47
7 0 p. m.....	18	24 5.7 N...	83 41 W...	646 R...	78	79	85	46
9 25 p. m.....	19	23 59 N...	83 45.5 W...	728 R...	74	77	82	42
May 14, 1872:								
0 3 a. m.....	20	23 50.9 N...	83 49 W...	892 R...	74	79	83	45
3 37 a. m.....	21	23 42 N...	83 52 W...	1,101 R...	76	80	82	45
7 5 a. m.....	22	23 33 N...	83 52 W...	826 R...	78	81	84	42
10 30 a. m	23	23 33 N...	83 52 W...	1,170 R...	84	80	82	41
12 36 p. m.....	24	23 28 N...	83 55 W...	1,313 R...	83	82	85	41
4 30 p. m.....	25	23 22 N...	83 58 W...	1,362 R...	84	82	90	40
May 15, 1872:								
4 57 a. m.....	26	23 18.7 N...	84 41.5 W...	1,140 R...	79	80	84	40
9 3 a. m.....	27	23 24.4 N...	84 40 W...	1,382 R...	79	81	84	42
12 30 p. m.....	28	23 29.5 N...	84 39 W...	1,694 R...	84	82	85	41
4 10 p. m.....	29	23 31.7 N...	84 32 W...	1,505 R...	82	82	84	40
8 55 p. m....	30	23 35.1 N...	84 23 W...	1,383 R...	80	81	84	41
May 16, 1872:								
0 59 a. m.....	31	23 39.3 N...	84 15 W...	1,528 R...	77	81	85	41
4 48 a. m.....	32	23 43 N...	84 10.6 W...	1,308 R...	77	81	84	40
8 40 a. m....	33	23 47 N...	84 1 W...	1,199 R...	79	82	85	41

XXXII.—CORRESPONDENCE WITH COMPANIES IN REFERENCE TO FACILITIES.

The railroads which favored the Commission in the transfer of the shad in 1873 were:

The Lake Shore and Michigan Southern, through Charles Paine, general superintendent, Cleveland, Ohio, and J. H. Parsons, superintendent western division, Chicago, Ill.

The Pennsylvania Railroad Company, by direction of Col. T. A. Scott.

The Orange, Alexandria and Manassas Railroad, through J. Fisher, general transportation agent, Alexandria, Va.

Burlington and Missouri River Railroad.

The Connecticut River Railroad, through Mr. Ward, depot-master, at Holyoke, Mass.

The Vermont Central Railroad.

The Toledo, Wabash and Western Railway.

The Chicago and Northwestern Railroad.

The Atlantic, Mississippi and Ohio Railroad, through F. N. Hugher, master of transportation, Lynchburgh, Va.

The Chicago, Burlington and Quincy Railroad.

On all the above roads the cans were carried as baggage, without extra charge, and access to them afforded at all times.

The New York Central Railroad.

The Boston and Albany Railroad.

New York, New Haven and Hartford Railroad.

Boston and Maine Railroad.

Maine Central Railroad.

European and North American Railroad.

These roads afforded access to the baggage-cars for attendants, and with many of them the amount charged as extra baggage tariff was a merely nominal sum. In the case of but one was any application made to its chief officers for favors.

COMMONWEALTH OF VIRGINIA,
OFFICE OF AUDITOR OF PUBLIC ACCOUNTS,
Richmond, *April* 30, 1873.

DEAR SIR: I was informed by Governor Walker a few days ago that application had been made to him for the use of one of our State steamers for the Fish Commissioners. I informed the governor that I could furnish one after the 1st of May. I write now to say that I have seen

O. A. Brown, esq., inspector for the third or Eastern Shore district, commanding the steamer Tredegar, and instructed him to be in readiness to serve the Commissioners at any time they may designate. As Captain Brown would like to have a few days' notice beforehand, so that he might make some additional arrangements on his boat for the accommodation of the Commissioners, I write to say that you can address him at Onancock, Accomack County, Virginia, and he will give prompt attention to your communication.

Further, I hope to obtain in a few days several documents upon the subject of the oyster-fisheries, which may be of interest to you in the preparation of your official report upon the subject of the fisheries, alluded to in your letter to Secretary McDonald.

I am, very respectfully,

WM. F. TAYLOR,
Auditor Public Accounts.

SPENCER F. BAIRD, Esq.,
Commissioner.

EXECUTIVE OFFICE,
WESTERN UNION TELEGRAPH COMPANY,
New York, July 17, 1873.

DEAR SIR: I take pleasure in inclosing herewith the letter of instructions to our managers requested in your letter to General Eckert, June 24. I have also forwarded the copy requested for Mr. Milner, Castleton, N. Y.

Very respectfully,

GEO. H. MUMFORD,
Vice-President.

SPENCER F. BAIRD, Esq.,
United States Commissioner, Portland, Me.

EXECUTIVE OFFICE,
WESTERN UNION TELEGRAPH COMPANY,
New York, December 26, 1873.

DEAR SIR: I have received your favor of the 23d instant, requesting letters in behalf of Mr. Livingston Stone and Dr. J. H. Slack, directing the acceptance at Government rates of their messages on the business of the United States Commission Fish and Fisheries. In reply I would say that I take pleasure in inclosing the letters, as requested.

Very respectfully,

GEO. H. MUMFORD,
Vice-President.

SPENCER F. BAIRD, Esq.,
United States Commissioner Fish and Fisheries, Washington, D. C.

ADAMS EXPRESS COMPANY,
No. 164 *W. Baltimore Street, Baltimore, Md., April* 23, 1873.

The agents of the Adams and Southern Express Companies will please extend to Prof. S. F. Baird, United States Fish and Fisheries Commissioner, every facility for the transportation from point to point of young fish for the purpose of stocking the rivers of the South and Southwest with shad.

Any attention by the agents and messengers to Professor Baird or his assistants, who will in each case accompany the packages of fish, by the way of securing prompt transmission of them, and the procuring of fresh water along the route during the stopping of the trains, will be doing a public service, and greatly oblige

Yours, respectfully,

SAML. M. SHOEMAKER,
Resident Manager Adams Express Company.

ADAMS EXPRESS COMPANY, BALTIMORE DIVISION,
Washington, D. C., June 7, 1873.

GENTLEMEN: It is the wish of Mr. S. M. Shoemaker, resident manager of this company at Baltimore, that you will render every facility in your power to the assistants of Prof. Spencer F. Baird, of the Smithsonian Institution, who are engaged in transferring living shad and other food-fishes for introduction in distant waters.

Any courtesy extended will be greatly appreciated and reciprocated by

Yours, respectfully,

G. W. MOSS,
Acting Agent.

TO AGENTS OF ADAMS EXPRESS COMPANY.

ADAMS EXPRESS COMPANY,
OFFICE OF THE GENERAL SUPERINTENDENT,
59 *Broadway, New York, June* 11, 1873.

To Agents and Messengers of Adams Express Company:

The bearer is one of the Commissioners appointed by the Government to stock the western waters with shad, and he is now *en route* in said capacity. I have to request that you will afford him every facility for the careful transportation of the spawn and small-fry he has in charge, and that you will aid him in every way possible in procuring fresh water and ice, and in such other manner as he may indicate.

Agents, at points where the Commissioner leaves spawn for deposit in the rivers or other streams of the vicinity, will request the aid of the local authorities, and invite them to witness that the spawn is properly deposited at the earliest possible moment after reception.

HENRY SANFORD,
General Superintendent.

WELLS, FARGO & COMPANY,
84 *Broadway*, *New York*, *June* 23, 1873.

DEAR SIR: In response to your favor of the 9th, we beg to hand you herein a letter addressed to agents by our general superintendent, Mr. Valentine, which will secure to your orders concerning the fish-shipments the requisite attention.

We remain, dear sir, yours very truly,

WELLS, FARGO & CO.

Hon. SPENCER F. BAIRD,
Commissioner, *Washington*.

WELLS, FARGO & COMPANY,
84 *Broadway*, *New York*, *June* 23, 1873.

DEAR SIR: Please extend to the Hon. Spencer F. Baird every facility likely to conduce to the successful transportation of the living fish about to be forwarded by him and by his order.

Please note particularly his directions concerning the care of the fish, and comply therewith, when you can do so without conflicting with our rules and regulations.

Yours, truly,

JNO. J. VALENTINE,
General Superintendent.

To AGENTS.

AMERICAN EXPRESS COMPANY,
President's Office, *Buffalo*, *June* 13, 1873.

DEAR SIR: I am this day in receipt of your letter of the 9th instant. As I wrote you last summer, we will do, cheerfully, all in our power to assist you in the matter of the distribution of fish among the western waters, and to that end I beg to inclose a circular-letter to our employés, requesting their co-operation.

If you will indicate the points where you specially desire to operate I will take pleasure in writing special letters on the subject.

Yours, truly,

WM. G. FARGO,
President.

SPENCER F. BAIRD, Esq.,
Commissioner, *Washington*, *D. C.*

AMERICAN EXPRESS COMPANY,
President's Office, *Buffalo*, *June* 13, 1873.

The agents, messengers, and other employés of this company are hereby requested to aid in every possible way the parties who are engaged in the transportation of live fish, with which to stock the western waters, under the direction of Hon. Spencer F. Baird, United States Commissioner Fish and Fisheries.

WM. G. FARGO, *President*.

AMERICAN EXPRESS COMPANY,
SUPERINTENDENT'S OFFICE, EASTERN DIVISION,
Albany, N. Y., July 1, 1873.

To Messengers Wheeler, Linn, and Vaden, or A. Van Hoesen, Agent, Castleton, N. Y.:

You may allow James W. Milner, assistant to United States Commissioner at Castleton, to ride with his fish, when sent by express, if he desires.

Yours, respectfully,

H. W. DWIGHT.

OFFICE OF UNITED STATES EXPRESS COMPANY,
Buffalo, N. Y., June 26, 1873.

Mr. James W. Milner, agent of the United States Fish Commissioners, is privileged to carry his cans of live fish in the cars of the United States Express Company, when there is space unoccupied, for one trip between Buffalo and Omaha, and he is also permitted to examine the same from time to time, as may be necessary.

If charges are unpaid, messengers will indorse hereon the number of cans and the gross weight of the same and return this to this office.

Yours, respectfully,

HENRY KIP,
General Superintendent.

By request of Spencer F. Baird, United States Fish Commissioner.

PENNSYLVANIA RAILROAD COMPANY,
OFFICE OF THE GENERAL MANAGER,
Philadelphia, Pa., June 4, 1873.

DEAR SIR: By direction of Colonel Scott, I have the pleasure to inclose an order to agents of this company, asking them to give your agents every assistance in their power, and directing baggage-masters to permit your agents to ride in the cars with the tanks, for the purpose of changing the water, &c.

Yours, truly,

A. J. CASSATT,
General Manager.

Prof. SPENCER F. BAIRD,
United States Commissioner of Fish and Fisheries, Washington, D. C.

PENNSYLVANIA RAILROAD COMPANY,
OFFICE OF THE GENERAL MANAGER,
Philadelphia, Pa., June 4, 1873.

Agents of the Pennsylvania Railroad Company are requested to give to the agents of the United States Commission on Fish and Fisheries every assistance they can, without interfering with their regular duties.

Baggage-masters will allow agents of the Commission, when provided with tickets, to ride in the baggage-cars, when it is necessary for them to do so, to attend to the tanks which they may have in charge.

This order is good until December 31, 1873.

A. J. CASSATT,
General Manager.

PENNSYLVANIA RAILROAD COMPANY,
OFFICE OF THE GENERAL MANAGER,
Philadelphia, Pa., January 5, 1874.

Agents of the Pennsylvania Railroad Company are requested to give to the agents of the United States Commission on Fish and Fisheries every assistance they can, without interfering with their regular duties.

Baggage-masters will allow agents of the Commission, when provided with tickets, to ride in the baggage-cars, when it is necessary for them to do so, to attend to the tanks which they have in charge. The tanks will be carried free of charge until July 1, 1874.

A. J. CASSATT,
General Manager.

THE NEW YORK CENTRAL AND
HUDSON RIVER RAILROAD COMPANY,
PRESIDENT'S OFFICE, GRAND CENTRAL DEPOT,
New York, June 13, 1873.

DEAR SIR: Yours of the 9th instant, stating that you propose to renew the experiment, inaugurated by Mr. Seth Green, of transporting fishes to California alive for purpose of propagation, and asking if we can carry them in cans on our express-train baggage-cars, is received.

We will carry them, as you suggest, in our baggage-cars, charging therefor the regular tariff-rates charged on all extra baggage carried in same way, and allow the party accompanying them access to the baggage-car for the purpose of aerating or changing the water to preserve life, said party to pay the regular passage-fare.

I inclose our tariff of extra-baggage rates from New York to all principal points west. If you desire to have the fish-cans checked through to points west of the terminus of this road, that is, beyond Buffalo or Suspension Bridge, the freight must be prepaid as far as checked, but if not checked you can pay freight only to either Buffalo or Suspension Bridge, and from there to terminus of the next road, and so on to destination.

Should you conclude to accept of this offer, please give me due notice, and also state from what point or points you propose to ship, that the necessary orders may be given to our agents.

Very truly,

W. H. VANDERBILT,
Vice-President.

SPENCER F. BAIRD,
Commissioner of Fish and Fisheries, Washington, D. C.

THE NEW YORK CENTRAL AND
HUDSON RIVER RAILROAD COMPANY,
PRESIDENT'S OFFICE, GRAND CENTRAL DEPOT,
New York, June 16, 1873.

DEAR SIR: The vice-president has made an arrangement with Mr. Spencer F. Baird, of United States Fish and Fishery Commission at Washington, to transport live fish in cans in the baggage-cars of this company from Castleton and Albany to points west, charging therefor the regular extra-baggage tariff-rates. The party who accompanies the fish, for the purpose of changing the water, is to be allowed access to the baggage-cars, but to pay the regular fare. Our superintendents have been notified of this, and will issue the necessary orders to conductors, and our Mr. Kendrick, the general passenger agent, will instruct the agents at Castleton and Albany as to the charges for transportation.

I notify you of the arrangements made by request of Mr. Baird.

Very truly,

J. P. CHAMBERS,
Private Secretary.

Mr. JAS. W. MILNER,
Castleton, N. Y.

THE NEW YORK CENTRAL AND
HUDSON RIVER RAILROAD COMPANY,
PRESIDENT'S OFFICE, GRAND CENTRAL DEPOT,
New York, June 16, 1873.

DEAR SIR: Yours of 14th received, and the necessary directions have been given to our superintendents as to granting permission to party accompanying fish to enter baggage-cars for the purpose of changing the water, and to our general passenger agent to notify the agents at Castleton and Albany as to the charges to be made for their transportation. Have also written Mr. Milner, informing him of our action.

Very truly,

W. H. VANDERBILT,
Vice-President.

SPENCER F. BAIRD, Esq.,
Washington, D. C.

OFFICE CENTRAL PACIFIC RAILROAD,
No. 9 Nassau Street, New York, June 16, 1873.

DEAR SIR: In acknowledging the receipt of your favor of the 12th instant, I would say that the authority of Mr. Towne extends over the Central Pacific Railroad and all its branches, and an order from him will be available from Ogden, Utah, west. For such facilities as you may need on the Union Pacific Road you will have to apply to the superintendent of that road. Your previous letter, under date of the 9th instant, was forwarded to Mr. Towne on the 11th instant, and you will, I have no doubt, in answer thereto, receive such facilities as you may need. If that will not be in time, I will telegraph Mr. Towne and get such an order as you speak of, which, as I understand, covers the transportation of the cans containing the fish in the baggage-car on express trains, and allowing your agent access to the car to give the fish necessary attention.

Truly yours,

J. E. GATES.

Hon. SPENCER F. BAIRD,
United States Commissioner of Fish and Fisheries,
Washington, D. C.

CENTRAL PACIFIC RAILROAD,
General Superintendent's Office, Sacramento, Cal., June 19, 1873.

DEAR SIR: Your letter to the president Central Pacific Railroad, New York, has been referred to this office. We will be prepared to move the fish, referred to as coming to California, in the baggage-car of our express-train at any and all times. If the transportation of the fish is to be attended to by Mr. Livingston Stone, he perfectly understands the mode of proceeding. If any other person, and you will give me the name, I will communicate with him, as far as our road is concerned, in regard to details.

Yours, truly,

JOHN CORNING,
Assistant General Superintendent.

SPENCER F. BAIRD, Esq.,
United States Fish Commissioner, Washington, D. C.

THE LAKE SHORE AND
MICHIGAN SOUTHERN RAILWAY COMPANY,
Cleveland, Ohio, June 19, 1873.

To Conductors and Baggage-masters:

You will please give all aid that is convenient and proper to Mr. James W. Milner, Deputy United States Commissioner of Fish and Fisheries, permitting his cans of living fish to be carried in the baggage-cars, and allowing him or his assistant to have such access to the cans, while in the baggage-cars, as they may desire.

CHARLES PAINE,
General Superintendent.

XXXIII.—REPORTS OF SPECIAL CONFERENCES WITH THE AMERICAN FISH-CULTURISTS' ASSOCIATION AND STATE COMMISSIONERS OF FISHERIES.

A—MEETING AT BOSTON, JUNE 13, 1872.

At a meeting of fish-commissioners and members of the American Fish-Culturists' Association, held at Boston June 14, 1872, the following gentlemen were present:

Prof. S. F. BAIRD, United States Commissioner; Dr. W. W. FLETCHER, New Hampshire; A. A. REED, Rhode Island; NEWTON DEXTER, Rhode Island; Dr. J. H. SLACK, New Jersey; E. A. BRACKETT, Massachusetts; C. A. WALKER, Massachusetts; B. F. BOWLES, Massachusetts; GEORGE SHEPARD PAGE, New York; and LIVINGSTON STONE, New Hampshire.

GEORGE SHEPARD PAGE was chosen chairman.

On taking the chair, he briefly stated that the meeting was brought about in consequence of a motion by Dr. Edmunds, fish-commissioner of Vermont, at the late meeting of the American Fish-Culturists' Association at Albany, that Congress be memorialized to make an appropriation for the purpose of propagating salmon and shad in the rivers of the United States.

Mr. Page said that he was honored with the chairmanship of the committee for this purpose, and he had called on the Committee on Appropriations, with Professor Baird, Mr. Walker, and Mr. Frye, member of Congress from Maine, to urge the requisite appropriation.

The committee of the House voted to grant an appropriation of $10,000, which was stricken out when the bill came up for consideration in the House; but in the Senate the item was restored, and increased to $15,000, thus giving this amount for the desired purpose; and Professor Baird, as United States Commissioner of Fish and Fisheries, was placed in charge of the disbursement of the sum. It was thought proper by him, on consultation with others, to have a meeting called at once of at least one representative from each State interested; and of the number invited, nine gentlemen were present on a very brief notice, while from others letters were received expressing regret at their inability, on so short a summons, to participate in the deliberations of the meeting.

A letter was read from W. Clift, one of the commissioners of Connecticut, giving his views of the importance of stocking the tributaries of the Mississippi with shad, and of expending the greater part of the appropriation in propagating the nobler fish.

Professor BAIRD spoke of the subject that it was proposed to discuss as one of great interest and one in which the country is vitally concerned.

When the proposition of the Fish-Culturists' Association was presented to Congress, it met with great favor. He found scarcely any one who objected to it at all. All with whom he had conversed agreed that it was important, and realized that State aid could not accomplish the object, and that the General Government must come in to assist; especially as the waters to be stocked belonged to many States, and it was not the interest of one State to provide fish for the others, inasmuch as what one State might sow the others might reap.

When this measure was first brought up in the House of Representatives, it was objected to because it was not in accordance with any pre-existing law, it being insisted that nothing shall be inserted in the regular appropriation-bills not intended to carry out some previous law, and a single objection can kill any such item. The matter, however, was only laid aside temporarily, and by presenting it to some Senators, especially Senator Edmunds, of Vermont, it was brought forward again, and he is perhaps entitled to the credit of having it put into the Senate bill, and a sum of $15,000 instead of $10,000 appropriated.

The idea of having shad introduced into the waters of the Mississippi River was specially favored by the members from the valley of the Mississippi, from Alabama and other Southern States. They all felt the necessity of increasing the number of fish, and wished every effort used to add to their supplies from this source; and the shad question was one which seemed practicable, because partial experiments in the Mississippi Valley have been made with great success. Two rivers in Alabama, one the Alabama, and the other the Escambia, have been stocked by private enterprise, and they are now catching the shad there. The fish were taken from the Alabama River some years ago; and from the Escambia so many have been taken during the past season as to have become quite an article of traffic. On this account, in part, the members of Congress from the Southern States were very much interested; and should even a partial success attend the present effort, it is likely hereafter to receive a strong support.

Of course, all thought that the most important fishes that can now be introduced into the waters were the shad and the salmon. The question in regard to the salmon is how and when the experiment can best be tried. If impregnated salmon-eggs are best for the purpose, where shall these be obtained? Can we get plenty of them in our own waters from the west coast, or shall we go to Europe? In regard to the western salmon, there are several difficulties in the way. In the first place, there are six, eight, or ten so-called species, probably six well-defined kinds. One serious objection has been made to the salmon of the west coast; and that is, they are said not to take the fly in fresh water. If this be true, shall we introduce fish that will not give sport to the angler? Nevertheless, it has lately been ascertained that they will take the fly outside of the mouths of the rivers. The Columbia River salmon will

bite in Shoal Water Bay, affording rare sport, although it is only a few years since this fact was ascertained. He did not remember to have seen any authentic statement of a salmon having been taken with the fly on the west coast. They can be caught in other ways; but whether they can be induced to rise at a fly in the eastern waters is perhaps questionable.

Again, according to the published accounts, many of these species are worthless; they are soft, white-meated, and not much better than cat-fish or suckers. Then, there is this fact, that one kind runs up in the spring and another in the fall; so that there are salmon almost all the time in the Columbia and in the Frazer; and there are said to be certain kinds that always die after spawning. The Indians say they all die; and the shores of the rivers are lined with dead fish, furnishing food for bears, hawks, &c. Probably, however, the white-meated fall-salmon or dog-salmon are in reality only the exhausted fish of the spring-run in the kelt condition, corresponding to what is known to occur in the European salmon. In this event, the number of species will be reduced.

If it be unadvisable to take these salmon from the West, is it worth while to encourage the idea of depending upon the Canadian government; or is it best to supplement our own stock by sending to Germany, Sweden, Norway, and Denmark, especially Norway and Germany? He invited any of the gentlemen present to give their views or make any suggestions on this subject.

Dr. SLACK heartily indorsed the suggestions of Professor Baird, believing that the General Government should co-operate with the States. Rivers were frequently the boundaries of the States, and the only hope of securing the propagation of fish in such cases was in the action of the United States. The people of New Jersey were anxious to stock the Delaware, but Pennsylvania could not agree, and thus nothing was done.

Mr. BRACKETT spoke of Mr. Atkins's experiments with reference to stocking the rivers of Maine with salmon, and his plan of purchasing them from the pounds and keeping them in ponds until the spawn is mature, and thus obtaining a stock of spawn for supplying the rivers. Mr. Atkins had not been successful in his first attempt; but having changed his plans somewhat, he now anticipated good results, and the method was now considered entirely feasible. His station is at Bucksport, Me., and he thinks he can furnish salmon for $4 a thousand, being furnished himself with the breeding salmon from weirs at the mouth of the Penobscot River.

Professor BAIRD inquired what should be done with the salmon-spawn, supposing it to be obtainable from the Penobscot.

Mr. BRACKETT thought it should be distributed among certain States, where salmon can be grown, according to population.

Professor BAIRD. Will it be desirable to add from the funds provided by the General Government to the State funds in the hands of State commissioners; or have they all the money they want?

Mr. BRACKETT said that if we had a thousand times as much as we now have, it would not be too much. Putting a few eggs in a stream amounts to nothing; they ought to be put in by millions.

Professor BAIRD. What States have provision for receiving this spawn and hatching it out?

Mr. BRACKETT mentioned Massachusetts, Maine, and New Hampshire as prepared to receive the eggs.

Mr. FLETCHER said his State could dispose of 100,000.

Mr. BRACKETT said that Dr. Fletcher was to place about 15,000 salmon-eggs in the headwaters of the Merrimack. He thought that seven or eight thousand had been placed there previously. Three small rivers in Massachusetts had received from one to three thousand, and this season, for the first time, the market has been teeming with salmon, weighing from two to three pounds, caught in weirs in Massachusetts Bay. In the town of Plymouth, the fishermen who sell fish from house to house carry around these small salmon. It is reasonable to suppose that these fish are the result of what has been done in stocking the rivers of New Hampshire and Massachusetts. There ought to be some law making it a penal offense to have these small salmon in one's possession. Unless possession of the fish be made a crime, the catching of them could not be prevented. None should be sold weighing less than four or five pounds.

Professor BAIRD stated that there was such a law in Nova Scotia.

Mr. REED said Rhode Island would be prepared very soon to place shad in two or three of the streams of that State. They had already hatched about 30,000 trout and 10,000 salmon, having obtained the spawn in Canada.

The question was then raised whether the salmon from Mr. Wilmot's establishment were the land-locked salmon; and it was concluded that it was of little consequence whether they were or not if they were equally good with the sea-salmon.

Dr. SLACK had had the true salmon and the land-locked, and could not tell which was which.

Mr. STONE said that the land-locked salmon when a year old has a black spot on the dorsal fin, which is not upon the true salmon.

Mr. BRACKETT said that some land-locked salmon would reach a weight of 17 pounds.

Mr. FLETCHER said they would average 10 pounds.

Mr. BRACKETT had seen one at the head of Sebago River that weighed $17\frac{3}{4}$ pounds.

Professor BAIRD inquired as to the propriety of attempting to introduce the land-locked salmon into the upper lakes. He thought that a good deal should be done in the way of experiments in the western waters, the Mississippi Valley, and the lake-regions, to stock them with shad or salmon.

Dr. SLACK thought that the petroleum discharged into the Ohio River had killed off the fish.

Mr. BRACKETT thought the Sebago salmon should be introduced into the upper lakes.

Mr. STONE understood that some of the salmon from Mr. Wilmot's establishment had been introduced into Lake Superior, in order to test the question whether they were land-locked and could subsist there. They have been there already two or three years.

Professor BAIRD said that Mr. Whitcher informed him that he had put some into Lake Huron. The small crustaceans of the genus *Mysis*, which is the principal food of the salmon on the coast of Great Britain and of Norway, are equally abundant in the deep waters of the great lakes. Mr. Milner had found this *Mysis* in water over 25 fathoms in depth. It is impossible to separate this shrimp-species from that of Labrador. The same thing was found in the stomachs of the lake white-fish. It is quite a common theory that the red color of the *Salmonidæ* is due to their feeding on small shrimps and other crustaceans.

Mr. BRACKETT said he had been informed that when they built the dam across the stream near Lake Sebago, they prevented the salmon from going down the lake; and in the course of time they bred very freely below, and are still taken clear down to tide-water; but that the flesh is of a clay-color or white, while all those in the lake itself are almost as dark-red as the sea-salmon.

Dr. SLACK said that the large trout which he had raised from the egg had white flesh, although those from which they came were red.

Similar results were stated by other gentlemen; and Dr. Slack said that although he stocked his ponds with red-fleshed trout, in a year or two the flesh became white. This is probably due to the absence of shrimps.

Professor BAIRD inquired whether those present would advise him to empower Mr. Atkins to obtain as many salmon-eggs as possible; and it was agreed to as desirable.

Dr. SLACK said New Jersey would take a portion of them.

Professor BAIRD expressed doubts as to the practicability of introducing the Penobscot salmon successfully south and west of the Hudson. He thought they would not get the proper temperature in the open rivers. It had been a theory that salmon were abundant in the Hudson; but he had seen a positive statement that they were never taken west of the Connecticut. The idea that salmon were in the Hudson River is based on the statement of Hendrick Hudson; and from the season of the year in which he professed to have seen them, and from the locality, there is not the slightest doubt that they were weak-fish. The oldest records of our own writers say nothing about salmon west of the Connecticut River. But Williams and Douglass, who both wrote a hundred years ago, state that in the Connecticut River they were very abundant, but none were to be found west of it. There is no doubt that they occurred in the Connecticut.

Mr. STONE stated that 3,000 salmon had been placed in the Connecticut recently, and some have been seen as the result.

Mr. SLACK inquired whether, as this is an object of national interest, it would not be well to purchase Seth Green's patent, which no doubt interfered much with fish-culture. He thought it would be a good way to expend a part of the money.

Professor BAIRD responded that that would have to be done, if at all, by direct action of Congress.

Mr. STONE thought that enough salmon-eggs could not be obtained from the State of Maine, and that it would be absolutely necessary to resort to the Pacific coast, where they can be gathered in any desired quantity. It was true there were many varieties, and some of them were worthless. There are one or two varieties, however, that are of good quality.

Professor BAIRD. The Quinnat salmon is said to be the best.

Mr. STONE. Some persons living on the Pacific coast consider them. the best in the world. If the whole appropriation of $15,000 were expended in purchasing all the salmon to be obtained from the State of Maine, there would not be anything near enough. We should have to go to the Pacific coast and put up large establishments, and then we could supply the rivers of the East with tens of millions. It would cost no more to get 10,000,000 eggs on the Pacific coast than to get 100,000 at the East. The question of stocking the large rivers is to be one of numbers. It cannot be done by putting a few thousand eggs in the rivers here and there, but we must put in millions of them; and there is no way of getting eggs by millions except from the Pacific coast.

Mr. BRACKETT thought that either the Saint Croix or the Sebago salmon should be looked after this year. He would prefer the Sebago to the Schoodic salmon, as they are the largest.

Mr. FLETCHER spoke of the number of eggs produced by a single salmon. He believed that there were more than 10,000 from a fish weighing ten pounds.

The question of stocking the Ohio and other tributaries of the Mississippi with shad was then more specifically considered.

Dr. SLACK said that until the 10th of July shad-spawn could be taken to the Ohio River. It takes about seventy-four hours to hatch them; and the eggs could be carried across from Springfield to the headwaters of the Ohio in less time than that.

Mr. BRACKETT thought it better to transport spawn than young fish.

Mr. FLETCHER said he had carried the eggs from the Connecticut River to the headwaters of the Merrimack, from Holyoke to Meredith, and hatched them out successfully in the Merrimack. The water can be changed more readily with spawn than with small fish. They may be kept in a vessel having a second one outside with ice in it. It will not do to put the ice in with the eggs.

Professor BAIRD spoke of the introduction of the carp, and inquired as to the views of the gentlemen present in regard to it.

Dr. SLACK spoke of the European carp as a very inferior kind of fish, and only palatable by the aid of French sauce. He thought the Sebago salmon the coming fish of America, and one that should have most attention devoted to it.

Mr. STONE referred to the British char as a fish to be recommended.

Professor BAIRD asked the opinion of gentlemen as to the sterlet.

Mr. PAGE had eaten the sterlet in Saint Peters burg, and considered it a delicious fish. He thought it the most valuable fish that could be imported from Europe. It is a hardy fish, and could be brought as young fry in a tank. They could probably be obtained from Berlin.

Mr. STONE called attention to the pike-perch as a fish also worthy of consideration.

Professor BAIRD spoke of the white-fish as one of the most important species in Lakes Michigan and Erie, but diminishing rapidly from many causes. It lives in the depths of the lakes, and formerly ran into many of the rivers in October and November to spawn, then returning. But the river-ways have been obstructed so much that they cannot go up excepting in the Saint Clair, Saint Mary's, the Nepeegon, the Michipicoten, and one or two other rivers, and therefore they shoot their spawn anywhere, and that has much to do with the decrease of the fish. The question has been agitated of establishing hatching-houses on the lakes, and producing them there in very large numbers, and then discharging them into the lakes, and let them furnish the stock for future growth. It is now too late to preserve their spawning-beds; but millions of them can be hatched out in different localities, and set adrift, which will keep up the supply. He was not sure but the best policy was to continue breeding them in that way year after year, in as large numbers as possible. If the waters are thus supplied with young fish, the ordinary means of capture will not destroy them. That is the true way in which the General Government can act to the best advantage by furnishing the eggs in large quantities and turning them loose into the waters; a moderate outlay will undoubtedly supply a great amount of food to the nation.

The subject of hybrids of the *Salmonidœ* was then briefly discussed.

Dr. SLACK had seen a hybrid between a white-fish and salmon-trout. It was a bad thing to teach trout to eat young fish; for after a short time they do not discriminate species.

Mr. BRACKETT said the Sebago salmon do not eat fish. He did not know what they fed upon; but he had taught them to eat curdled milk.

Mr. STONE thought they would learn very readily to eat each other.

Dr. SLACK said that in feeding trout he would give a great deal of food at a time, as otherwise the smaller fish would not get their share.

The meeting then adjourned.

B—MEETING IN NEW YORK, OCTOBER 19, 1872.

Professor BAIRD said he had invited those present to attend this meeting, in order that he might communicate something as to what he

had done, as United States Commissioner of Fish and Fisheries, in the disposition of the appropriation by the Government, and the introduction of useful food-fishes into rivers and lakes of the United States.

He referred to the action of the meeting of the Fish-Culturists' Association at Albany in February last, and the appointment by it of a committee to visit Washington and memorialize Congress, of which Mr. George Shepard Page was chairman. The efforts made by Mr. Page were stated, resulting ultimately in the final passage of an appropriation of $15,000 for the contemplated work.

Reference was made to the late date at which the bill was passed, and the necessity of calling a meeting of fish-commissioners and fish-culturists for advice as to the best manner of applying the appropriation. A meeting was held for this purpose on the 13th of June in Boston, and some conclusions were arrived at, more particularly with reference to the introduction of shad into certain streams at once, as the season had nearly closed when it would be possible to do this.

The arrangements made with Messrs. Green and Clift, and the results of their work, were stated, namely, the placing of several thousand young shad in the Allegany at Salamanca, and in the Mississippi at Saint Paul, and in Lake Champlain, by Mr. Green; and a much larger number at Salamanca, in the White River at Indianapolis, and in the Platte at Denver, by Mr. Clift.

The question whether shad could be successfully planted in the more southern and western rivers was alluded to, and the opinion expressed that all the rivers emptying into the Atlantic could be thus stocked As to the Mississippi and its tributaries, experiment alone could decide its susceptibility to sustain shad; though there was no reason why this might not be the case, while the fact that shad are now, and have been for many years, taken in the Ouachita River, goes to show that the experiment of stocking other tributaries of the Mississippi would be likely to succeed. If shad can ascend to the vicinity of Hot Springs, Ark., as they do, there is no good reason why they may not go higher.

Dr. GOLDSMITH, of Vermont, said he had taken shad at the falls of the Ohio River several years since.

Professor BAIRD concluded that, as far as the question with reference to the shad is concerned, there is every reason to look with hope to the future. The next most important fish to be considered was the salmon. These formerly abounded in the rivers of the New England States, but never occurred spontaneously west of the Connecticut River, or at least of the Housatonic. The fish referred to by Hendrick Hudson, which was caught in September in large numbers in the vicinity of New York, and described by him as the salmon, was undoubtedly the squeteague, or weak-fish, (*Cynoscion carolinensis.*)

Salmon were formerly plenty in Lake Champlain and in Lake Ontario, but whether the Ontario salmon went to the ocean and returned again has not been determined. There is little doubt that every river in the

United States, having suitable physical conditions, can be stocked with salmon. The true salmon (*Salmo salar*) is adapted to the waters throughout New England and possibly to the lakes. There are salmon in the Pacific waters which differ from the eastern species, and which make their way through water of a far higher temperature than that of most of the streams on the Atlantic coast. The Sacramento River during the past summer was exposed to a heat of from 100 to 115 degrees in the shade, and the upper part of the valley is perhaps one of the hottest places in the United States. But still salmon abound in that river, and it is believed that fish taken from that locality will have an equal power of resisting heat on this side of the Rocky Mountains.

The recommendation of the meeting at Boston was first attended to, of co-operating with the commissioners of the States who were disposed to supply Mr. Atkins with the funds necessary to carry on his experiment on the largest possible scale. He had already begun his work, and a general plan of operations was arranged, by which he was authorized to purchase as many salmon as were offered to him in good, healthy condition. These he obtained from the fishermen of the Penobscot, and placed them in a pond embracing 150 acres, within a central inclosure of about 5 acres, to be kept till the period of spawning. With the funds thus supplied him by the United States Commissioner and the State commissioners, he procured six hundred salmon, varying in weight from 5 to 25 pounds, of which number nearly all survive, and the prospect of a large number of eggs from this source was very encouraging. These, at the proper time, were to be distributed among the parties contributing to the expense of procuring them.

As this supply was not likely to be as great as was desired, application was made to the *Deutsche Fischerei-Verein* in Germany, and through their instrumentality the German government had been induced to offer to the United States a quarter of a million eggs of the Rhine salmon from the national establishment at Hüningen. Besides this number, half a million had been engaged from the establishment of Mr. Schuster in Freiburg. It was expected that both these lots would be placed in charge of Mr. Rudolph Hessel, an experienced fish-culturist, for transfer to the place of shipment, and that possibly he would accompany them to America. These were expected some time in January, and if possible another quarter of a million would be procured from the same source.

In accordance with the suggestion of the meeting at Boston, Mr. Livingston Stone had been sent to California, and had established himself on a branch of the Sacramento River, unfortunately, however, too late in the season; yet, from this source several thousand eggs were expected, which would be placed in the Susquehanna and Delaware.

The report of operations by Mr. Stone, as forwarded to the United States Commissioner, was then read.

The Commissioner then called upon the gentlemen present for any sug-

gestions as to the best localities for the introduction of the different kinds of salmon expected, and also as to the expediency of procuring certain other kinds of fish, either from abroad or our own waters, for introduction into streams where they do not now occur. He also asked as to the number and kinds of eggs of salmon expected to be available that the different gentlemen present would receive and provide for hatching and distributing them into appropriate streams.

Dr. EDMUNDS, of Vermont, said he had made inquiries in regard to the waters emptying into Lakes Champlain and Ontario, and found that salmon were formerly plenty in them. Some of the people in the vicinity of these waters make a distinction between the salmon of the lake and what they call the Bay Chaleur salmon, which were found in all the rivers up to the Oswego, but in what respect these differed from each other he could not learn. Salmon have been gone from Lake Champlain since 1824, where, at one time, they were exceedingly abundant. Since dams have been built, they have gradually disappeared, and people think the dams and sawdust killed them. The sawdust undoubtedly acts injuriously by covering the spawning-beds.

Mr. SETH GREEN said that salmon used to occupy the streams emptying into Lake Ontario, except the Genesee, clear to Niagara, on both sides. A good many still run up to the head of Lake Ontario, and up Wilmot's Creek, which is only ten or twelve miles long. He did not regard these as land-locked salmon, though they may never go down the Saint Lawrence; they may find the requisite food in Lake Ontario. He hoped that shad would also find appropriate food in the lakes, as he had placed some in the Genesee River in 1871, and he had seen some this summer 4½ and 5 inches long, and some had been caught in Lake Ontario that would weigh a quarter of a pound, and were over 8 inches long.

Salmon placed in the rivers of New York will grow and go to sea and come back as far as the first dam if not taken by pound-nets, but as long as pound and trap nets are allowed we can never restock our rivers The salmon is strictly a shore-fish, never being caught far from the shore; a pound-net will catch every fish that follows along the coast.

The Delaware would be a good river for salmon if it were not for the pounds. There are trout in the headwaters of that river; and any rivers that have trout in their headwaters will be suitable for salmon. Over-fishing is the cause of the scarcity of salmon and other fish in this country. They must all be hatched and kept up artificially, in order to have a supply in the future.

Until we have better fish-ways than have hitherto been made, we cannot have salmon. They should be distributed when hatched into small streams, so that they will have plenty of food. You will never have salmon till pounds are abolished.

Mr. BRACKETT. The salmon have been killed out of the waters of Massachusetts for the last twenty-eight years. The Massachusetts commissioners succeeded in getting a few thousand, and distributing them in

the headwaters of certain streams. This was three years ago, and this year, for the first time, the market in Boston has had a great many salmon, weighing from two to three pounds, taken in gill-nets set for mackerel. Almost every man in the fish-market in this city has had salmon, weighing from one to three pounds, brought from the east, and unquestionably the fish which the Massachusetts commissioners placed in the rivers of that State. The only way to prevent the taking of these small salmon would be to pass a law, making it a penal offense to have any such fish weighing less than five pounds for sale or in one's possession.

Mr. THADDEUS NORRIS said he was an old salmon-fisher, and had given the subject of fish-propagation considerable attention, and had learned a good deal about the habits and instincts of salmon. The salmon that Mr. Wilmot, of Canada, procures is a fresh-water fish. The fish of the lakes have lost their sea-going instinct. Lake Ontario is their wintering-place; and they live there all the year when not going up the streams to spawn; this done, they go back into the lake. The Sebago salmon, he thought, was once a fish that went to the sea regularly; and that they are the same as the regular sea-going salmon.

Dr. EDMUNDS said he saw salmon in Montreal that had herring in them. This he thought an evidence that they feed in the rivers.

Mr. BRACKETT thought the herring were probably taken before the salmon entered the fresh water. No man could say he had ever taken salmon with minnows in its stomach.

Mr. NORRIS thought the salmon of Lake Ontario were fresh-water salmon, for the reason that they had minnows in them. He had visited Saint John many times, and had been assured by Mr. Venning that there were true salmon in Lake Lomond, which supplies the water for the city of Saint John; that they are called white-fish there, having deteriorated in size. The fish, having gone up from the sea, had been retained there, and now could not get back. Mr. Norris himself believed them to be true salmon, and had seen them there not more than 8 or 9 inches long.

Mr. BRACKETT said that the Sebago salmon had been known to weigh 17 pounds.

Mr. NORRIS. The obstructions were once removed and salmon then ran up to Lake Lomond again. He thought there would be no difficulty in stocking all the western lakes with salmon if an appropriation were make to continue the work now begun. He thought the Sacramento salmon should be placed in the northern rivers; he did not know where the Rhine salmon should be placed. The Susquehanna and Delaware he thought would be suitable for the Sacramento salmon. They can go fifty miles above tide-water in the Susquehanna, even up into the State of New York. He hoped New Jersey and Pennsylvania would be remembered in the distribution of the eggs obtained from the Sacramento. And he would be glad to try in those States the Rhine and the Penobscot salmon. They had facilities for hatching them in tributaries of the Susquehanna near Harrisburgh.

To show how simple a matter it is to stock a river with salmon, he related the experience of himself and others in placing 12,000 young fish in the Delaware last year. He obtained the eggs of Mr. Wilmot, and they were kept until the yelk-sac was absorbed, and then turned into the small streams, where they were able to take care of themselves. There was very little trouble in the operation, and no care of feeding them was required. There are now 13,000 salmon in the Delaware.

Mr. SETH GREEN related his practical experience as a fisherman and dealer in fish for many years on Lake Ontario. In the course of his operations, he had dressed tons of salmon, and never saw anything in them that really amounted to anything. They were taken in a trap-net in the lake; and the trap-nets killed them all out of Lake Ontario in about five years. They were set near the shore all along the lake.

The first pound-net came from Scotland in about 1836. It was a curious contrivance, that took a great many salmon. After much effort, he got an opportunity to go out to the net, the construction of which was kept a secret, and assisted in taking out the fish, and after working for some weeks in that way he got the idea of the whole thing, and then went into the business himself. After five years, only a few salmon were left, and these came into Wilmot Creek, and another creek at Grafton.

Mr. REED. Are you satisfied that the Sacramento salmon will rise to the fly?

Mr. GREEN. Yes, I know they will; when the right man goes with the right kind of tools, he will get them fast enough.

In answer to Mr. HOWELL, who inquired if salmon, in passing up the Delaware would be likely to pass along the shores or in the channel, as the question would have an important bearing on the Delaware River fisheries, there being nets placed near the shore for a long distance, Mr. Green said he thought they would keep the center of the stream. When he spoke of salmon being a shore-fish, he meant to be understood as saying that the ocean-salmon pass along the shore.

Mr. NORRIS. In the tidal waters of the Delaware, would they follow the channel or shore?

Mr. GREEN. Both.

Mr. PIKE said that having some curiosity to investigate the question of the similarity of the salmon from Mr. Wilmot's stream and those of the Penobscot, he had three of each sent him last winter. He examined them carefully, and they were examined by others, and no one could see any difference. There was more real difference between those that came from the Penobscot than between them and the Wilmot stream salmon. That was the only way to test the question, to bring them side by side.

In regard to the expense of hatching salmon, he said his apparatus cost him only $3, and he hatched out a thousand without the slightest difficulty. He lost about three hundred. The water used came through lead-pipe, being that used in the city.

Professor BAIRD, with reference to the introduction of sea-salmon into the lakes, said he had full confidence that the experiment would be successful with the Penobscot salmon.

It is well known that the food of the salmon, in the North Atlantic, consists largely of small shrimps, about half an inch long, belonging, to a considerable extent, to the genus *Mysis*, and which occur in great abundance. Two years ago, some investigations were made in the deep waters of Lake Superior and Lake Michigan, in which the dredge and other improved apparatus were employed. To the surprise of the gentlemen engaged in this work, this very shrimp was found at a depth below 25 fathoms. It there constitutes, to a great extent, the food of the white-fish being very generally found in its stomach.

The fact that the gastric juice of fishes continues to act after their death is one reason why so little is found in the stomachs of those which feed on minute, soft-bodied animals, if not examined immediately after they are caught. After a few hours, nothing but a microscopic examination will tell what a fish feeds upon.

The occurrence of this small crustacean in the larger lakes is the guarantee that the salmon will thrive there. Anadromous fish placed in a river are led by their instinct to follow the current down to some large body of water. When they get down from the rivers to the lakes, they find this large body of water, and in Lake Superior or other large lakes they are practically in the ocean. They do not know the road through the waters except by a current, or else by a route which they have previously traversed. Their instinct teaches them to go down the river to the sea, and to return; and they cannot get into the wrong river any more than a man will mistake his own house.

Fishermen at Halifax had told him during the past summer that it is very common for salmon, after they have spawned, to go into the lakes and spend the winter there. They are perfectly ravenous, and can be taken easily. They go down in the spring to the sea, and back again at the proper spawning-season.

Many white-fish have precisely the same habit; in certain fresh-water lakes they run up into the streams in summer, and winter in the lakes. In Hudson's Bay, the white-fish winter, and are taken there in immense numbers. They run up from the bay into the rivers exactly as they do in some of the rivers of Lake Superior or Lake Michigan. Therefore there is every reason to believe that the great lakes can be stocked with salmon to any desirable extent.

Dr. GOLDSMITH said that during the time when negotiations were going on between the British government and our own, he made an effort to secure legislation to permit the passage of fish up the Saint Lawrence, which is the great artery by which our lakes must be supplied with sea-going fish; and the matter being referred to the Secretary of State, it was brought to the attention of the Canadian authorities, who assured him (Dr. G.) that it was only necessary for those interested in

the fisheries of the great northern lakes to state what legislation was necessary in order to permit the easy and safe ascent of fish seeking to go up the rivers, and it would be done. He, therefore, thought this meeting a fit occasion for the formation of some plan, and to confer with some persons connected with the Canadian government, with a view to procure such legislation on the part of the Canadian authorities and on the part of the States of the Union which are concerned, as will secure an easy and safe migration of fishes to the lakes.

Professor BAIRD said he met Mr. Mitchell, the commissioner of the Dominion, last summer, and he said that if existing regulations were not sufficient they should be made so. Their own existing regulations are very stringent as to time and other particulars. Mr. Mitchell manifested the utmost cordiality, and offered any aid that he could render in the prosecution of the work of the United States Fish Commissioner in the Bay of Fundy, even to the extent of tendering the service of a government steamer if it was desired. He also gave free permission to take fish in any waters of the Dominion, any law to the contrary notwithstanding. It is as much for the interest of the Dominion as our own that the work on the border has been prosecuted; and salmon are to be placed in the Saint Croix, which is the boundary-line between the United States and New Brunswick.

Mr. GREEN. Pound and trap netting is prohibited on the Dominion coast. He said he had great faith in the feasibility of stocking our small lakes with salmon-trout, and at a small cost. He expected to have a great abundance of salmon-trout spawn, and would gladly send to any of the States whose commissioners wished to try the experiment a quantity of the eggs.

Mr. NORRIS. Will salmon-trout do well in the Susquehanna?

Mr. GREEN. No, sir; but they will probably grow to a good size in trout-streams where the trout have been exterminated. They rise to the fly. All our great lakes and the inland smaller lakes can be stocked in three or four years with as many fish as they ever had. But he would not recommend the effort until pound-fishing is stopped.

Professor BAIRD inquired if any one had experimented upon hybrids of the *Salmonidæ*.

Mr. GREEN said he had crossed the white-fish with the salmon-trout, and the salmon with the salmon-trout, but never raised them.

Professor BAIRD referred to experiments made in Europe, where it is becoming an important branch of fish-culture to produce hybrids, promising the best results.

The subject of the introduction of new species of fish was then considered, and the opinions of several gentlemen were given as to the varieties which might be properly tried.

Mr. CLIFT deprecated the introduction of the Danube salmon, (*Salmo hucho.*) He thought that salmon could go up the Mississippi to the headwaters.

Professor BAIRD said that question, as far as distance was concerned, was settled affirmatively by the fact that salmon do go up the Yukon River and the Frazer. The Yukon is at least two thousand miles in length, and the ascent must be much more fatiguing to fish than that of the Mississippi, on account of rapids and obstructions in the former river. In the Yukon, the salmon has to fight his way to the mountains, while in the Mississippi there is nothing to hinder his progress.

Mr. GREEN further spoke of the necessity of the removal of obstructions from the rivers, so that fish may have a free run to the upper waters, and he advocated a close time at least for all pounds and traps.

Doctor EDMUNDS said the authorities in Vermont had come to the conclusion that the only way to stock their streams was by artificial propagation, and a law would probably be enacted by which towns might stock their rivers with trout and then charge a royalty for fishing in them.

Mr. NORRIS then spoke of the manner in which Mr. Green holds his patent for a hatching-trough, and thought the Government ought to buy the patent and have the right to its use everywhere. He also urged the importance of action by the General Government in stocking all such streams as are the boundaries of States, and where it is difficult to procure concurrent legislation on the part of the States themselves. He thought there should be an application for at least $30,000 or $40,000 at the next session of Congress for this work of fish-propagation.

Colonel WORRALL thought that the ova coming from California should all go into one stream, so as to make the experiment on as large a scale as possible.

Mr. GREEN wanted enough fish put into whatever stream received any to do somebody some good.

Mr. HUDSON also thought the Sacramento salmon should be placed in a stream west of the Hudson. He would be willing to relinquish any claim to them.

Mr. NORRIS thought some of the Rhine salmon should go to Dr. Slack, to be placed in the Delaware or Susquehanna.

Professor BAIRD stated that the salmon of the Rhine prefer a temperature below 60°, and when it rises to 65° they retreat to the sea and wait until by some rise in the river, on account of rain, the temperature is diminished.

Mr. HOWELL inquired how early salmon would ascend the Delaware.

Professor BAIRD thought that they would probably go up in April or May.

Dr. GOLDSMITH called attention to a matter which concerned more especially those separated from the sea, and with whom fish-culture must relate to fresh-water fishes only, such as trout. The question which had been presented to his mind was one which lies at the economy of fish-culture. How many pounds of fish-food, muscular fiber, does it take at a given temperature of the water to produce a pound of trout?

and what, with a given cost of food, is the absolute cost of a pound of trout, the first, second, and third year of feeding?

He said he had made some experiments in this direction himself, and he desired to bring the matter to the attention of the meeting, with a view to secure some experiments by others living in different parts of the country, for the purpose of determining this fact, and thereby settling the question whether fish culture is profitable or simply a congenial amusement. He therefore moved that the United States Commissioner of Fish and Fisheries be requested to address a letter to such persons as are now engaged in the culture of the trout, which shall contain recommendations from himself, and which shall secure the careful performance of the necessary experiments, and prescribe the method by which the questions shall be determined.

This motion was agreed to.

The subject of fish-ways was then considered and discussed, and the various forms of those constructed by Colonel Worrall and others were briefly explained.

Dr. HUDSON spoke of the obstruction at the Holyoke dam, which prevents the ascent of shad.

Mr. PIKE said no expense was spared in Connecticut to make one of the finest fish-ways, but shad had never gone through it.

Colonel WORRALL said all the plans of the New England fish-ways he had seen were not more than 4 or 5 feet wide, whereas the narrowest part of his own was 20 feet wide. The wider they are the better.

Mr. PAGE referred to the meeting of the American Fish-Culturists' Association, held in Albany last February, and to his appointment upon a committee to enter into correspondence in regard to fish-culture in China and Japan. He had communicated with the State Department in regard to this subject, and had met with a favorable response; and, singularly enough, he had just received a letter from Japan, which he would read.

The letter is as follows:

No. 113.] "UNITED STATES CONSULATE,
"*Kanagawa*, *September* 5, 1872.

"SIR: Referring to your dispatch No. 60, I have the honor to report, that from the best information within my reach I glean the following facts:

"In Japan there is no scientific or business method of propagating fish. The great abundance of salt-water fish and the fact of but little being used which is not previously salted do not seem yet to involve the necessity of propagation.

"A few Daimios, chiefly in the south, and also in Kinishin, have transferred *live* fish when young (not two inches long) from river to river, from river to pond, and from pond back to river again. They are transferred in small, flat vessels of water, and put into temporary artificial ponds made of puddled clay, only a few inches deep, and covered with netting to keep the fish safe from attack of birds.

"The gold-fish are treated in this way, as are also a kind of fish called koi, which resemble somewhat carp, but are rounder. They are fed on very small worms, dug out of mud at the bottom of stagnant and slow-running ditches. At the end of three weeks or so, the pond is made to communicate by a channel, either with a larger pond of old standing or a river, and the artificial pond is thus emptied of its stock. This is done in Hizen and Bingo for ornament of gardens.

"Salmon abound in the rivers on the western coast of Nipon, north of this latitude, as do also black bass. Yesso and its rivers teem with salmon, the fishing for which by net on the sea-shore begins about the 1st of September, and ends about the 27th of November.

"Fishing for salmon by net is at present going on about 85° northeast from this port on the Pacific coast.

"I have the honor, sir, to be your obedient servant,

"C. O. SHEPARD,

"*Consul.*

"Hon. CHARLES HALE,

"*Assistant Secretary of State, Washington.*"

After the reading of this letter, the meeting adjourned.

XXXIV.—BIBLIOGRAPHY OF REPORTS OF FISHERY COMMISSIONS.

By Theodore Gill.

[The following list, made by Prof. Theodore Gill, of the official reports of State fishery-commissions, has been carefully prepared, and includes all thus far published that could be procured. A list of the commissioners of each year is also inserted.—Spencer F. Baird.]

A—NAMES OF COMMISSIONERS.

Alabama.

1871–'74: Charles S. G. Doster; Ro. Tyler; D. R. Hundley.

California.

1870–'71: B. B. Redding; S. R. Throckmorton; J. D. Farwell.

1872–'74: S. R. Throckmorton; B. B. Redding; J. D. Farwell.

Connecticut.

1866–'67: F. W. Russell; Henry C. Robinson.

1867–'68: H. Woodward; James Rankin; James A. Bill.

1869–'70: William M. Hudson; Robert G. Pike; Sam. H. Lord.

1870–'71: Robert G. Pike; William M. Hudson; James A. Bill.

1871–'74: William M. Hudson; Robert G. Pike; James A. Bill.

Iowa.

1873–'74: Samuel B. Evans; B. F. Shaw; C. A. Haines.

Maine.

1867–'68: Nathan W. Foster; Charles G. Atkins.

1868–'71: Charles G. Atkins.

1871–'74: E. M. Stilwell; Henry O. Stanley.

Maryland.

1874: T. B. Ferguson; Philip W. Downs.

Massachusetts.

1856–'57: R. A. Chapman; Henry Wheatland; N. E. Atwood.

1865–'66: Theodore Lyman; Alf. A. Reed.

1867–'69: Theodore Lyman; Alfred R. Field.

1869–'70: Theodore Lyman; Alfred R. Field; E. A. Brackett.

1870–'71: Theodore Lyman; E. A. Brackett.

1871–'72: Theodore Lyman; E. A. Brackett; Thos. Talbot.

1872–'73: E. A. Brackett; Thos. Talbot.

1873–'74: Theodore Lyman; E. A. Brackett; Asa French.

Michigan.

1873: John J. Bagley; George H. Jerome; George Clark.

1874: George Clark; A. D. Kellogg; John J. Bagley.

MINNESOTA.

1874: Horace Austin; David Day; O. W. Latham.

NEW HAMPSHIRE.

1865–'69: Henry A. Bellows; W. A. Sanborn.

1869–'72: Thomas E. Hatch; William W. Fletcher.

1872–'73: William W. Fletcher; W. A. Sanborn; Thomas E. Hatch.

1874: Oliver H. Noyes; John S. Wadleigh; A. C. Fifield.

NEW JERSEY.

1870–'72: B. P. Howell; J. H. Slack.

1872–'73: B. P. Howell; J. H. Slack; J. R. Shotwell.

1874: B. P. Howell; J. R. Shotwell; G. A. Anderson.

NEW YORK.

1868: Horatio Seymour; Seth Green; Robert B. Roosevelt.

1869–'71: Horatio Seymour; George G. Cooper; Robert B. Roosevelt.

1872–'74: Horatio Seymour; Edward M. Smith; Robert B. Roosevelt.

OHIO.

1873–'74: John H. Klippart; John Hussey; E. Sterling.

PENNSYLVANIA.

1870–'72: James Worrall.

1872–'73: H. J. Reeder; Ben. L. Hewit; James Duffy.

RHODE ISLAND.

1868–'69: Alfred Reed; Albert S. Gallup; S. S. Foss; C. H. Tompkins; E. D. Pearce.

1871–'74: John H. Barden; Newton Dexter; Alfred A. Reed, jr.

VERMONT.

1865–'69: Albert D. Hager; Charles Barrett.

1867: Albert D. Hager; Charles Barrett.

1869: Albert D. Hager; Charles Barrett.

1870–'74: M. C. Edmunds; M. Goldsmith.

VIRGINIA.

1871: William B. Ball; Asa Wall.

WISCONSIN.

1873–'74: William Welch; Alfred Palmer; P. R. Hoy.

B—BIBLIOGRAPHY OF REPORTS.

UNITED STATES.

Memoranda of inquiry | relative to the | food-fishes of the United States. [Washington: Government Printing-Office. 1872. 8vo, 5 pp.; without title-page.]

Questions relative | to the | food-fishes of the United States. [Washington: Government Printing-Office. 1873. 8vo, 7 pp.; withou title-page.]

Statistics of the menhaden fisheries, etc. [Questions addressed to fishermen, etc.—Washington, December 20, 1873.—4to, letter-form, 2 l.]

[Draught of law for legislative protection of fish, by the Commissioner.—fol., bill-form, 6 pp.]

United States Commission of Fish and Fisheries. | — | Part 1. | — | Report | on the | condition of the sea-fisheries | of the | south coast of New England | in | 1871 and 1872. | By | Spencer F. Baird, | Commissioner. | — | With supplementary papers. | — | Washington: | Government Printing-Office. | 1873. | [8vo, xlvii, 852 pp., 40 pl., with 38 l. explanatory (to pl. 1–38), 1 folded map.]

I. Report of the Commissioner, [S. F. Baird.] pp vii–xlvii.*

II. General plan of inquiries prosecuted. [1. Memoranda of inquiry relative to the food-fishes of the United States. 2. Questions relative to the food-fishes of the United States.] pp. 1–6.

III. Testimony in regard to the present condition of the fisheries, taken in 1871. pp. 7–72.

IV. Special arguments in regard to regulating the sea-fisheries by law. pp. 73–103.

V. Reports of State commissions in regard to regulating the sea-fisheries by law. pp. 104–124.

VI. Report of conference of the United States Commissioner with commissioners of Rhode Island and Massachusetts, held October 5, 1871. pp. 125–131.

VII. Draught of law proposed for the consideration of, and enactment by, the legislatures of Massachusetts, Rhode Island, and Connecticut. pp. 132–134.

VIII. Miscellaneous correspondence and communications on the subject of the sea-fisheries. pp. 135–138.

IX. European authorities on the subject of regulating the fisheries by law. pp. 139–148.

X. Notices in regard to the abundance of fish on the New England coast in former times. pp. 149–172.

XI. Statistics of fish and fisheries on the south shore of New England. pp. 173–181.

XII. Supplementary testimony and information relative to the condition of the fisheries of the south side of New England, taken in 1872. pp. 182–195.

XIII. Pleadings before the senate committee on fisheries, of the Rhode Island legislature, at its January session of 1872. pp. 196–227.

XIV. Natural history of some of the more important food-fishes of the south shore of New England [viz: the scup (*Stenotomus argyrops*) and the blue-fish (*Pomatomus saltatrix*)]. pp. 228–252.

XV. Description of apparatus used in capturing fish on the

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* This portion, with the general title-page, (pp. i–xlvii,) was issued in advance separately.

sea-coast and lakes of the United States. pp. 253–274, with 19 (1–19) figs. and pl. (maps) xxxix and xl, and large folded map.

XVI. List of patents granted by the United States to the end of 1872 for inventions connected with the capture, utilization, or cultivation of fish and marine animals. pp. 275–280.

XVII. List of the sea-weeds or marine algæ of the south coast of New England. By W. G. Farlow, M. D. pp. 281–294.

XVIII. Report upon the invertebrate animals of Vineyard Sound and the adjacent waters, with an account of the physical characters of the region. By A. E. Verrill. pp. 295–778, with pl. i–xxxviii.

XIX. Catalogue of the fishes of the east coast of North America. By Theodore Gill. pp. 779–822.

XX. List of fishes collected at Wood's Hole, [between June 20 and October 4.] By S. F. Baird. pp. 823–827.

XXI. Table of temperatures of the little harbor, Wood's Hole, Mass., from January 1, 1873, to December 31, 1873. pp. 828–831.

XXII. List of illustrations. p. 833.

XXIII. General index. pp. 835–852.

42d Congress, 3d session. House of Representatives. Mis. Doc. No. 86. | = | Fish-propagation for food. | Letter | of | Professor Baird, | relative to | an appropriation for the propagation of food-fishes in the rivers of the | United States. [Washington: Government Printing-Office. 1873. 8vo, 7 pp.]

NOTE.—Without title-page.

43d Congress, 1st session. House of Representatives. Mis. Doc. No. 235. | = | Appropriation for preservation of food-fishes. | — | Letter | of the | United States Commissioner of fish and fisheries, | asking | a deficiency appropriation for the fiscal year ending June 30, 1874. [Washington: Government Printing-Office. 1874. 8vo, 8 pp.]

ALABAMA.

Report | of the | commissioners to encourage | fish-culture, | submitted to the | governor of Alabama, | January 26th, 1872. | — Montgomery, Ala.: | W. W. Screws, State printer. | — | 1872. [8vo, 7 pp.]

CALIFORNIA.

1. Report | of the | commissioners of fisheries | of the | State of California | for | the years 1870 and 1871. | [Seal.] | Sacramento: | T. A. Springer, State printer. | 1872. [8vo, col. title, 24 pp.]
2. Report | of the | commissioners of fisheries | of the | State of California | for | the years 1872 and 1873. | — | San Francisco: | Francis & Valentine, printers and engravers, 517 Clay street. | 1874. [8vo, 28 pp.]

CONNECTICUT.

1. Report | of the | commissioners | concerning the protection of fish | in the | Connecticut River, &c., | to the | general assembly, | May session, 1867. | — | Printed by order of the legislature. | — | Hartford: | Case, Lockwood and Company, printers. | 1867. [8vo, 25 (+1) pp., 1 pl.]
2. Report | of the | commissioners on fisheries, | to the | general assembly, | May session, 1868. | New Haven: | Thomas J. Stafford, State printer. | 1868. [8vo, 28 pp.]
3. Report | of the | commissioners of fisheries | to the | general assembly, | May session, 1869. | — | Middletown: | A. Newton & Son, printers. | 1869. [8vo, 18 pp.]
4. Fourth report | of the | commissioners of fisheries | of the | State of Connecticut, | 1870. | Hartford: | Case, Lockwood & Brainard, printers. | 1870. [8vo, 37 pp.]
5. Fifth report | of the | commissioners of fisheries | of the | State of Coicnnectnt, | 1871. | - | Hartford: | Case, Lockwood & Brainard, printers. | 1871. [8vo, 46 pp.]
6. Sixth report | of the | commissioners of fisheries | of the | State of Connecticut. | 1872. | — | Hartford: press of Case, Lockwood & Brainard. | 1872. [8vo, 36 pp.]
7. Seventh report | of the | commissioners of fisheries | of the | State of Connecticut. | 1873. | — | Hartford, Conn.: | press of Case, Lockwood & Brainard. | 1873. [8vo, 48 pp.]
8. Eighth Report | of the | commissioners of fisheries | of the | State of Connecticut, | 1874. | — | Hartford: | press of the Case, Lockwood & Brainard Co. | 1874. [8vo, 36 pp.]

MAINE.

1–2. Reports | of the | commissioners of fisheries | of the | State of Maine | for the years | 1867 and 1868. | — | Augusta: | Owen & Nash, printers to the State. | 1869. [8vo, 96 pp., 2 pl.; 43 pp., 1 l.]

CONTENTS.

First report—1867. [Part 1, pp. 3–96; part 2, pp. 41–43 (index).]
Second report—1868. [Part 2, pp. 1–39, 45.]

3. Third report | of the | commissioner of fisheries | of the | State of Maine, | 1869. | — | Augusta: | Sprague, Owen & Nash, printers to the State. | 1870. | [8vo, 48 pp., 1 pl.]

   NOTE.—The plate illustrates the black bass (*Micropterus salmoides*).

4. Fourth report | of the | commissioner of fisheries | of the | State of Maine | for the year | 1870. | — | Augusta: | Sprague, Owen & Nash, printers to the State. | 1870. [8vo, 56 pp., 2 pl. (1 folded).]

   NOTE.—The plates are diagrams of fish-ways for salmon.

5. Fifth report | of the | commissioner of fisheries | of the | State of Maine | for the year | 1871. | — | Augusta: | Sprague, Owen & Nash, printers to the State. | 1872. [8vo, 30 pp., 1 l., 1 pl.]

   NOTE.—The plate represents the embryology of the salmon.

6. Sixth Report | of the | commissioners of fisheries | of the | State of Maine, | for the year | 1872. | Augusta: | Sprague, Owen & Nash, printers to the State. | 1873. [8vo, 16 pp.]

7. Seventh report | of the | commissioners of fisheries | of the | State of Maine, | for the year | 1873. | Augusta: | Sprague, Owen & Nash, printers to the State. | 1874. [8vo, 39 pp.]

NOTE.—A plate representing the sexual organs of the American lobster, drawn by Sidney I. Smith, was loosely inserted in the later issues of this report.

MARYLAND.*

No report on true fishes published yet.

MASSACHUSETTS.

[Senate..No. 193.] Report of commissioners | appointed | under resolve of 1856, chap. 58, | concerning the | artificial propagation of fish, | with | other documents. | — | Boston: | William White, printer to the State. | 1857. [8vo, 1 col. title-page, 54 pp.]

NOTE.—Contains (pp. 19–54) a translation of the article on pisciculture by Jules Haime from the "Revue des deux mondes," June, 1854.

Senate..No. 8. | = | Commonwealth of Massachusetts. [The report of commissioners, appointed May 3, 1865, "concerning the obstructions to the passage of fish in the Connecticut and Merrimack Rivers." Boston, 1866. 8vo, 77 pp., 1 pl. folded.]

NOTE.—Without title-page; the title given under the unbracketed caption being repeated from the governor's message transmitting and prefatory to the report.

1. House..No. 3 | = | Commonwealth of Massachusetts. | — | Report | of the | commissioners of fisheries. | — | Boston: | Wright & Potter, State printers 1867. [8vo, 7 pp., 1 pl.]

NOTE.—The first report of the commissioners of fisheries appointed under chapter 238 of the acts of 1866; without separate title page.

2. House..No. 60. | = | Report | of the | commissioners of fisheries, | for the year ending | January 1, 1868. | — | Boston: |

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*The following special reports on the oyster-fisheries are noteworthy:

1. Report | upon the | oyster resources | of Maryland | to the | general assembly, | by | Hunter Davidson, esq., | com. State oyster police force. | — | Annapolis: | Wm. Thompson of R., printer. | — | 1870. [8vo, 20 pp.]

2. Report | on the | oyster fisheries: | Potomac River shad and herring fisheries, | and the water fowl of | Maryland | to his excellency the governor, | and other | commissioners of the State O. P. force, | January, 1872. | — | Annapolis: | S. S. Mills, L. F. Colton & Co., printers. | 1872. [8vo, 48 pp.]

3. Report | of the | commander | of the | oyster fisheries and water fowl | of | Maryland, | to his excellency the governor, | and the | commissioners of the State O. P. force. | January 1st, 1874. | — | Annapolis: | Wm. T. Iglehart & Company, | printers to the senate. | — | 1873. [8vo, 11 pp.]

NOTE.—On cover, dated 1874.

4. The | oyster law of Maryland. | January session, 1874. | An act to repeal article seventy-one of the code of | public general laws, title | "Oysters," | as amended and re-enacted by chapter three hun- | dred and sixty-four, of the acts passed at Janu- | ary session, eighteen hundred and seventy, | and also chapter one hundred and sixty-seven of the acts passed at the January | session, eighteen hundred and | seventy-two. | — | Annapolis: | S. Sands Mills & L. F. Colton, | printers to the house of delegates. | 1874. [8vo, 13 pp.]

Wright & Potter, State printers, | No. 4 Spring Lane. | 1868. [8vo, 50 pp., 3 pl.]

NOTE.—With pl. i representing "embryo American shad (*Alosa præstabilis*)" in 7 fig., and pl. ii representing hatching-apparatus, etc.

3. Senate..No. 3. | = | Report | of the | commissioners of fisheries, | for the year ending | January 1, 1869. | — | Boston: | Wright & Potter, State printers, No. 79 Milk street, | (corner of Federal street.) | 1869. [8vo, 71 pp.]
4. Senate..No. 12. | = | Report | of the | commissioners of fisheries, | for the year ending | January 1, 1870. | — | Boston: | Wright & Potter, State printers, | 79 Milk street, (corner of Federal.) | 1870. [8vo, 67 pp., 1 pl. representing embryos and newly-hatched of *Salmo* (fig. 1, 2, 5, 8, 10), *Alosa* (3), *Perca* (4), *Osmerus* (6, 7), and fungus of eggs.]
5. Senate..No. 11. | = | Fifth annual report | of the | commissioners | on | inland fisheries. | — | January, 1871. | — | Boston: | Wright & Potter, State printers, | 79 Milk street (corner of Federal). | 1871. [8vo, 77 pp.]
6. Senate..No. 3. | = | Sixth annual report | of the | commissioners | on | inland fisheries, | for the year ending January 1, 1872. | — | Boston: | Wright & Potter, State printers, 79 Milk street (corner of Federal). | 1872. [8vo, 78 pp., 2 pl., 1 folded table, + (appendix) 1 p. l., 270 pp.]
7. Senate..No. 8. | = | Seventh annual report | of the | commissioners | on | inland fisheries, | for the | year ending January 1, 1873. | — | Boston: | Wright & Potter, State printers, 19 Province street. | 1873. [8vo, 35 pp, 3 pl. folded.]

MICHIGAN.

Pisciculture, or fish-farming. | An address | before the | legislature of Michigan | on the | artificial propagation of fish, | and the | restocking of the public waters | of the State. | Delivered at Lansing, February 28, 1871, | by Hon. N. W. Clark, | of Clarkston, Mich. | Detroit: | Tribune Book and Job Office. | 1871. [8vo, 23 pp.]

Propagation of fish: | an address to the legislature, | by N. W. Clark.

NEW HAMPSHIRE.

1. Report | of the | commissioners on fisheries, | made to the | legislature of New Hampshire, | June session, 1866. | Concord: | George E. Jenks, State printer. | 1866. [8vo, 16 pp.]

NOTE.—The second report was not published separately.

3. Report | of | the commissioners | on | inland or river fisheries, | June session, 1868. | Manchester: | John B. Clarke, State printer, | 1868. [8vo, 8 pp.]
4. Report | of | the fish-commissioners | to the | legislature, June session, 1869. | Manchester: | John B. Clarke, State printer. | 1869. [8vo, 10 pp.]

5. Report | of the | commissioners on fisheries | of the | State of New Hampshire, | June session, 1870. | Manchester: | John B. Clarke, State printer. | 1870. [8vo, 15 pp.]
6. Report | of the | commissioners on fisheries | of the | State of New Hampshire, | June session, 1871. | Nashua: | Orren C. Moore, State printer. | 1871. [8vo, 11 pp.]
7. Report | of the | commissioners on fisheries | of the | State of New Hampshire, | June session, 1872. | — | Manchester: | James M. Campbell, State printer. | 1872. [8vo, 15 pp.]
8. Report | of the | commissioners on fisheries | of the | State of New Hampshire, | June session, 1873. | Nashua: | Orren C. Moore, State printer, | 1873. [8vo, 13 pp.]

NEW JERSEY.

1. First annual report | of the | commissioners of fisheries | of the | State of New Jersey. | 1871. | — | Trenton, N. J.: | Murphy & Bechtel, book and job printers—State Gazette Office. | 1871. [8vo, 25 pp., 4 maps (2 folded).]

   NOTE.—The maps represent the Delaware River at Scudder's Falls, etc.

2. Second annual report | of the | commissioners of fisheries | of the | State of New Jersey. | 1872. | — | Trenton, N. J. | Printed at the Gazette Office. | 1872. [8vo, 22 pp.]
3. Third annual report | of the | commissioners of fisheries | of the | State of New Jersey | for the year 1872. | — | Trenton, N. J.: | the State Gazette Office—Murphy & Bechtel, book and job printers. | 1872. [8vo, 28 pp.]
4. Fourth annual report | of the | commissioners of fisheries | of the | State of New Jersey for the year 1873. | — | Trenton, | N. J. | the State Gazette. | — | Murphy & Bechtel, book and job printers. | — | 1873. [8vo, 32 pp., appendixes.]

NEW YORK.

1. Fisheries of the State of New York. | — | Report | of the | commissioners of fisheries | of the | State of New York, | giving the number, names, location, and areas of all | the lakes within the State of New York, the | coast-lines of lakes Ontario and Erie, | and that portion of the State | bordering on the ocean, | with a map, | showing the lakes, streams in the State, | railroad and canal lines. | — | Transmitted to the legislature March 9, 1869. | — | Albany: | Weed, Parsons & Co., printers and publishers. | 1869. [8vo, 75 pp., 1 folded map.]
2. Report | of the | commissioners of fisheries | of the | State of New York. | — | Transmitted to the legislature March 11th, 1870. | — | Albany: | The Argus Company, printers. | 1870. [8vo, 20 pp.]
3. Report | of the | commissioner of fisheries | of the | State of New

York. | — | Transmitted to the legislature February 28, 1871. | — | Albany: | The Argus Company, printers. | 1871. [8vo, 32 pp.]

4. Fourth annual report | of the | commissioners of fisheries | of the | State of New York. | — | Transmitted to the legislature March 19, 1872. | — | Albany: | The Argus Company, printers. | 1872. [8vo, 34 pp.]
5. Report | of the | commissioners of fisheries | of the | State of New York. | — | Transmitted to the legislature February 12, 1873. | — | Albany: | The Argus Company, printers. | 1873. [8vo, 32 pp.]
6. Report | of the | commissioners of fisheries | of the | State of New York. | Transmitted to the legislature February 5, 1874. | Albany: | Weed, Parsons and Company, printers: | 1874. [8vo, 39 (+ 2) pp., 8 pl.]

   NOTE.—The plates represent the New York State hatching-house, etc.

OHIO.

Report | of the | commissioners of fisheries | of the | State of Ohio, | for the year ending December, 1873. | — | Columbus: | Nevins & Myers, State printers. | 1874. [8vo, 40 pp. (with 5 cuts).]

NOTE.—The first report.

An essay | on | fish-culture. | By John H. Klippart. | — | Read before the Ohio State agricultural convention, 1873. | — | Columbus: | Nevins & Myers, book-printers. | 1873. [8vo, 20 pp., 1 cut.]

PENNSYLVANIA.

1. Commonwealth of Pennsylvania. | — | Report | of the | commissioner for the restoration | of the | Inland Fisheries, | for the year 1870. | — | Harrisburg: | B. Singerly, State printer, | 1871. [8vo, 48 pp.]

   NOTE.—Reprinted, with separate pagination, from the "Miscellaneous documents read in the legislature of the commonwealth of Pennsylvania," [etc.,] session of 1871, pp. 979–996.

2. Report of the commissioner for the restoration of the Inland | Fisheries for the year 1871. | <Miscellaneous documents read in the | Legislature of the | commonwealth of Pennsylvania | during the session which commenced at Harrisburg January 21, 1874. | Harrisburg: B. Singerly, State printer. | 1872. [8vo, pp. 259–274.]

   NOTE.—The plates are diagrams of fish-ladders; the first being identical with the first in the fourth New Hampshire report, 1870.

3. Commonwealth of Pennsylvania. | — | Report | of the | commissioner for the restoration | of the | Inland Fisheries, | for the year 1871; | including his | special report to the senate | on the | subject of fish-ladders. | — | Harrisburg: | B. Singerly, State printer. | 1872. [8vo, 24 pp., 2 pl. (1 folded).]

4. Commonwealth of Pennsylvania. | — | Report | of the | State commissioners | of | fisheries, | for the year 1873. | — | Harrisburg: | Benjamin Singerly, State printer. | 1874. [8vo, 30 pp., 1 pl.

RHODE ISLAND.*

1? State of Rhode Island, &c. | = | Report | of the | commissioners to investigate the practicability of re-stocking | the waters of the State with salmon and other migratory fish. [1869. 8vo, 16 pp.]

NOTE.—Without title-page.

2. Report | of the | commissioners of internal fisheries, | presented February, 1872. | — | Appointed by the governor in accordance with chap. 920, sec. 1st, "An act in | amendment of chap. 848 of the public laws," entitled "An act for the encouraging and regulating inland fisheries," passed March 21st, 1871. | — | Providence: | A. Crawford Greene, printer to the State. | 1872. [8vo, 16 pp.]

3. State of Rhode Island, &c. | = | Third annual report | of the— commissioners of inland fisheries, | made to the | general assembly | at its | January session, A. D. 1873. | — | Providence: | Providence Press Company, printers to the State. | 1873. [8vo, 8 pp. + (appendix) 1 l. (= pp. 11–12).]

4. State of Rhode Island, &c. | = | Fourth annual report | of the | commissioners on inland fisheries, | made to the | general assembly at its January session, | A. D. 1874. | — | Providence: | Providence Press Company, printers to the State. | 1874. [8vo, 10 pp.]

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* On account of the special interest of and information contained therein, the folowing documents are noteworthy:

State of Rhode Island, &c. | — | Majority report | of the | committee on fish eries. | January session, A. D. 1870. [8vo, 6 pp.]

NOTE.—Recommendation of act prohibiting (conditionally) trapping fish, signed by Jabez W. Mowbray, Thomas G. Carr, Ezra J. Cady, Henry T. Grant, committee.

State of Rhode Island, &c. | Minority report | of the | committee on fisheries. | January session, A. D. 1870. [8vo, 3 pp.]

NOTE.—Signed by John G. Childs, one of the committee.

Acts and resolves | passed at the | January session | of the | general assembly | of the | State of Rhode Island | and Providence Plantations | 1870. | 0 | Providence: | Providence Press Company, tate printers. | 1870. [8vo, xii, 245 pp.]

Report | of the | joint special committee | of the | general assembly of Rhode Island, | appointed to examine into the | fisheries of Narragansett Bay. | — | May session, A. D. 1870. | — | Pawtucket: | Nickerson & Sibley, book and job printers. | 1870. [8vo, 158 pp., 1 l.]

Majority report | of the | committee on fisheries. | January session, A. D. 1870. [8vo, 6 pp., + minority report, 3 pp.]

Views | in relation to | protecting fish | in the | tide-waters of the State. [1871. 8vo, 12 pp.]

NOTE.—Without title-page.

(N. B.—Laid before the assembly, May, 1871.)

[Minority report to the senate of the committee on fisheries. By Albert Coggeshall. March, 1872. 8vo, 4 pp.]

UTAH.

Report | of | Deseret Agricultural | and | Manufacturing Society, | for the years | 1872–3. | David O. Calder, public printer, Salt Lake City, Utah. | 1874. [8vo., 1 col. title, 7 pp.]

NOTE.—Contains (pp. 5–7) a report to the "Hons. Wilford Woodruff, George Q. Cannon, and A. M. Musser, directors of Zion's Co-operative Fish-Association," by A. P. Rockwood, superintendent, on "the progress in the piscatorial department during the year ending December 31st, 1873."

VERMONT.

Report | made under authority | of the | legislature of Vermont, on the | artificial propagation of fish, | by | George P. Marsh. | — | Burlington: | Free Press print. | 1857. [8vo, 52 pp. + (appendix) = 62 pp., 1 l.]

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1. Report of commissioners | relative to the | restoration of sea-fish | to the | Connecticut River and its tributaries. | — | By order of the legislature of Vermont. | — | Annual session, 1866. | — | Montpelier: | Freeman steam printing establishment. | 1866. [8vo, 35 pp.]

   NOTE.—First report.

2. Report | of the | fish commissioners | of the | State of Vermont. | By | Albert D. Hager and Charles Barrett. | For the year 1867. | — | Montpelier: | Walton's steam printing establishment. | 1867. [8vo, 25 pp.]

   NOTE.—Second report.

3. Report | of the | fish commissioners | of the | State of Vermont. | By | Albert D. Hager and Charles Barrett. | For the year 1869. | — | Montpelier: | Poland steam printing establishment, | Journal building, State street. | 1869. [8vo, 16 pp.]

   NOTE.—Third report; none made in 1868.

4. Report | of the | fish commissioners | of the | State of Vermont | by | M. C. Edmunds and M. Goldsmith, | for the years 1871–2. | — | Montpelier: | J. & J. M. Poland's steam printing establishment. | 1872. [8vo, 20 pp.]

   NOTE.—Fourth report; none made for 1870.

An address | on | fish culture. | Delivered before the | legislature of Vermont, | on Tuesday evening, November 12th, 1872. | — By — | Middleton Goldsmith, M. D. | — | Rutland: | Tuttle & Co., printers. | 1872. [8vo, iv, 16 pp.]

VIRGINIA.*

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* The following report is noteworthy:

Report | to the | auditor of public accounts | on the | oyster beds | of | Virginia; | by | Orris A. Browne, | inspector for 3d district of Virginia. | — | Richmond: | Shepperson & Graves, printers. | 1872. [8vo, col. title, 21 pp.]

LIST OF ILLUSTRATIONS.

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MAPS.

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Fig. 1

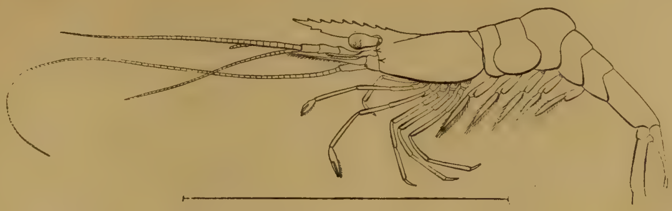
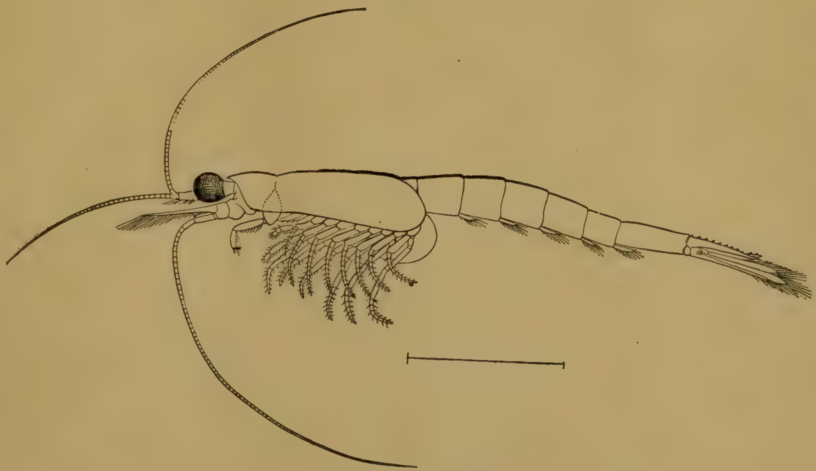


Fig. 2.



No. 518

Fig. 3

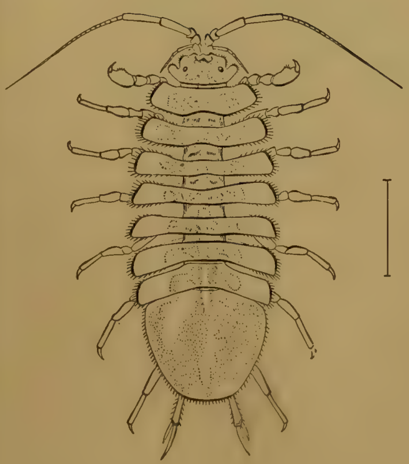


Fig. 4

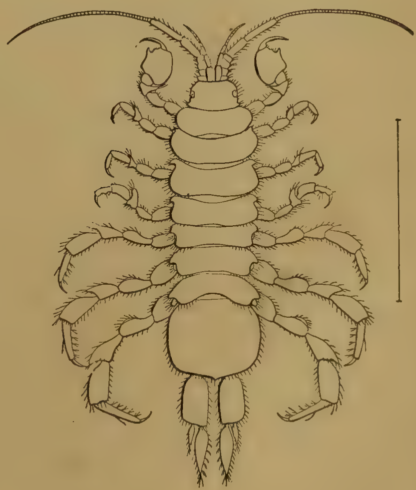


Plate II.

Fig. 5.

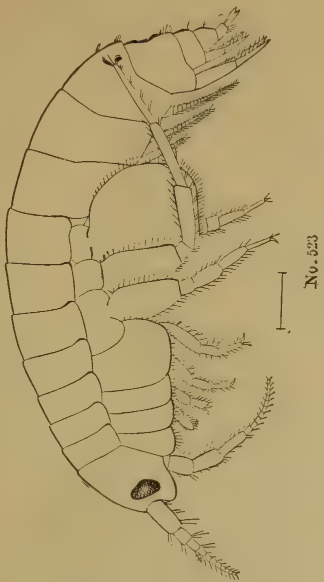


Fig. 6.

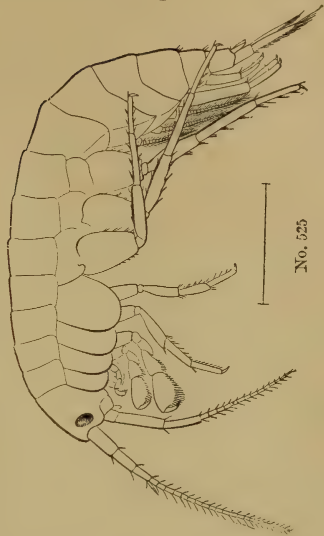


Fig. 10

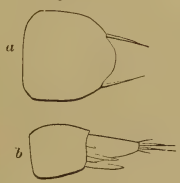


Fig. 9

Fig. 7

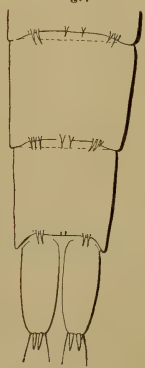


Fig. 8

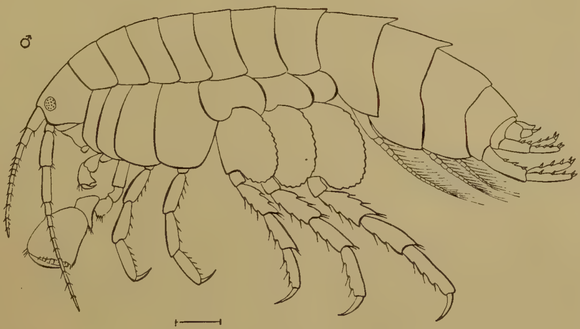
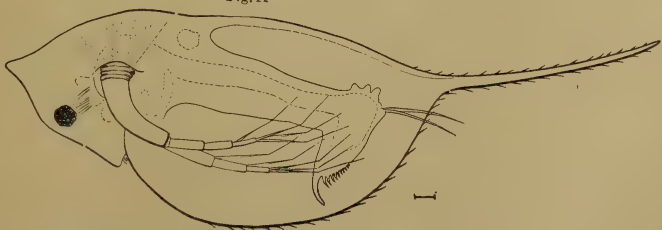


Fig. 11



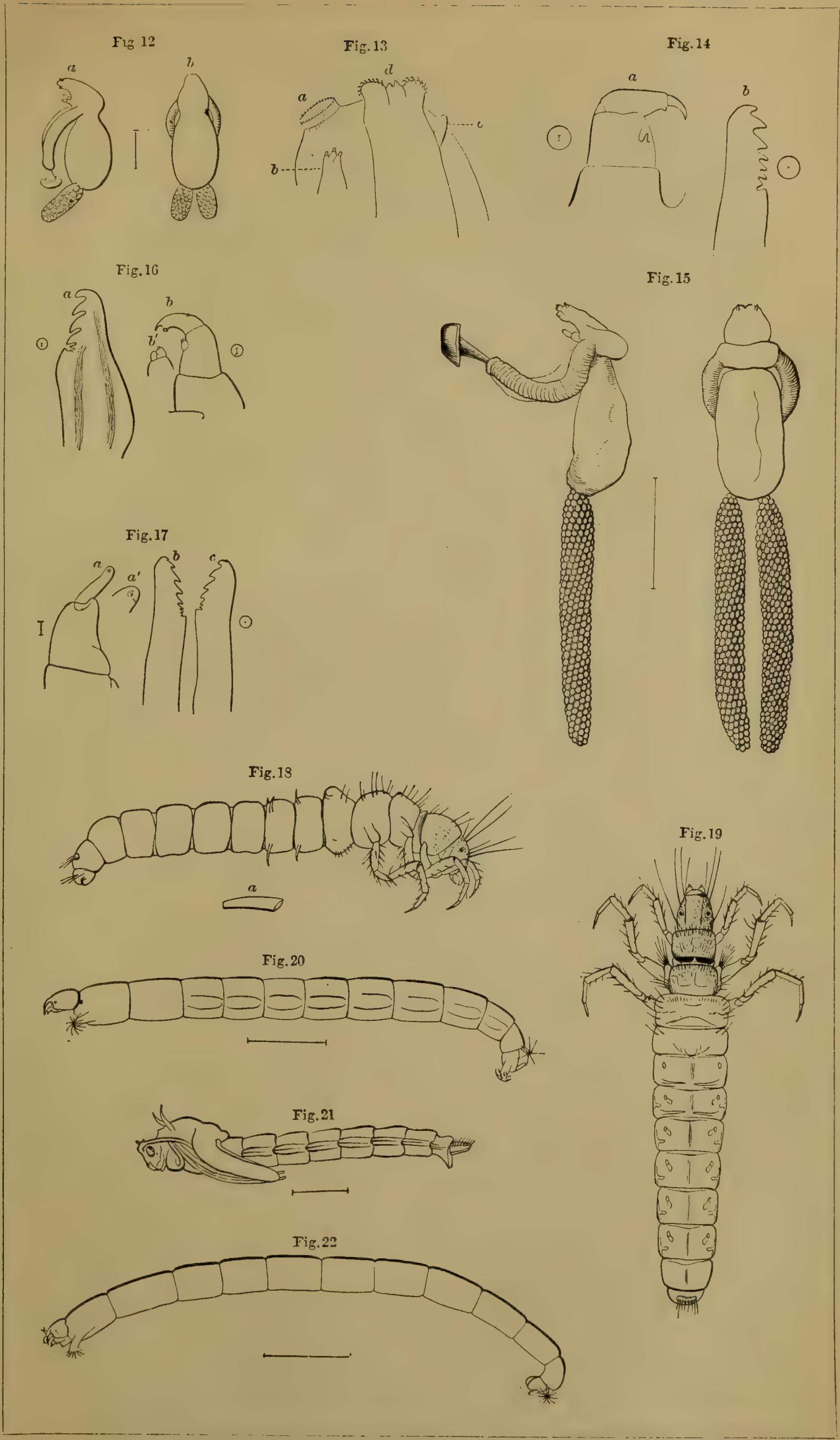

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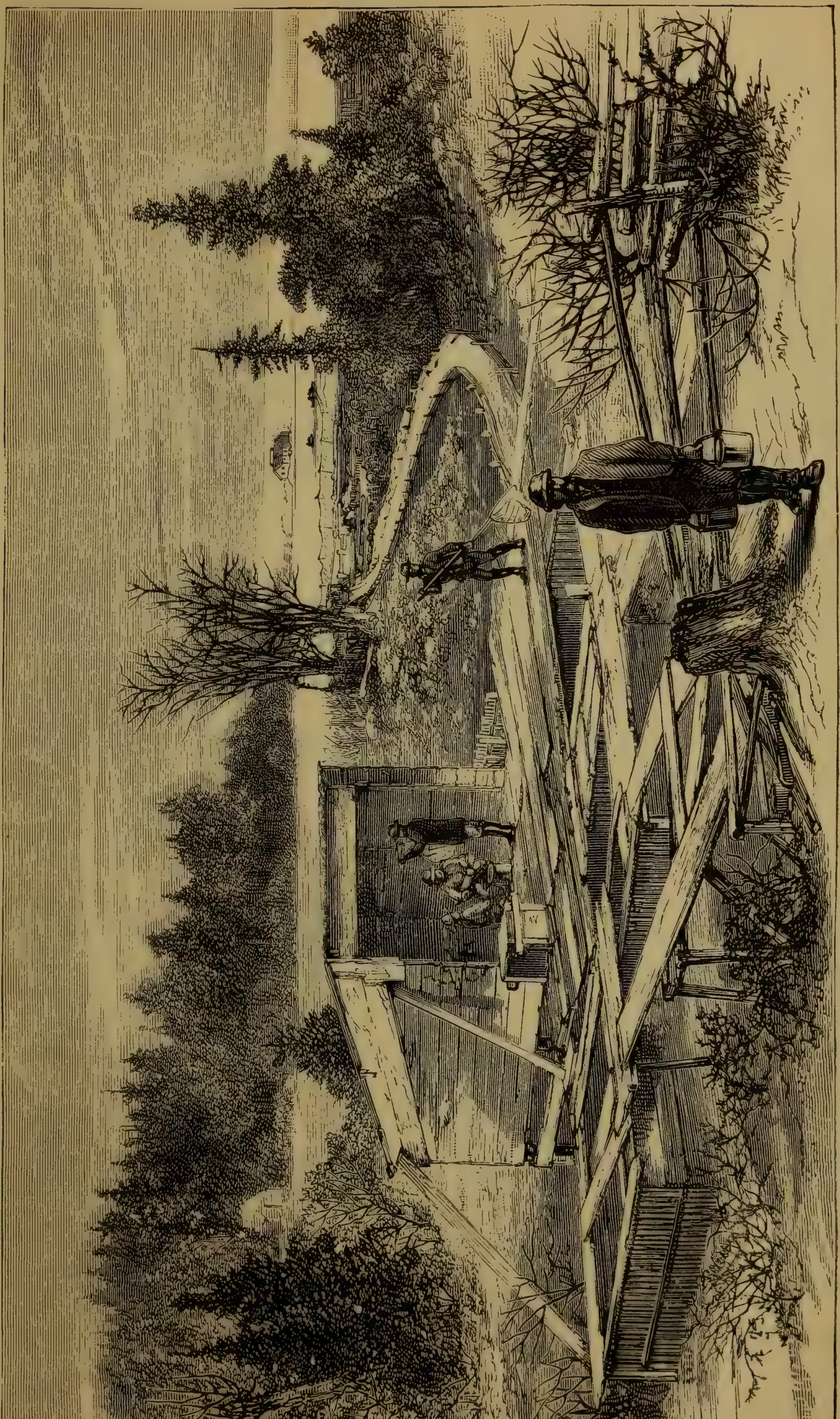
Fig. 22

Plate IV.



View of Salmon-pens and Spawning-shed, Bucksport, Me. From Harper's Magazine.

Fig. 1.—Interior of Spawning-shed, Bucksport, Maine. From Harper's Magazine.

Fig. 2.—Interior of Salmon-hatching House, Bucksport, Me. From Harper's Magazine.

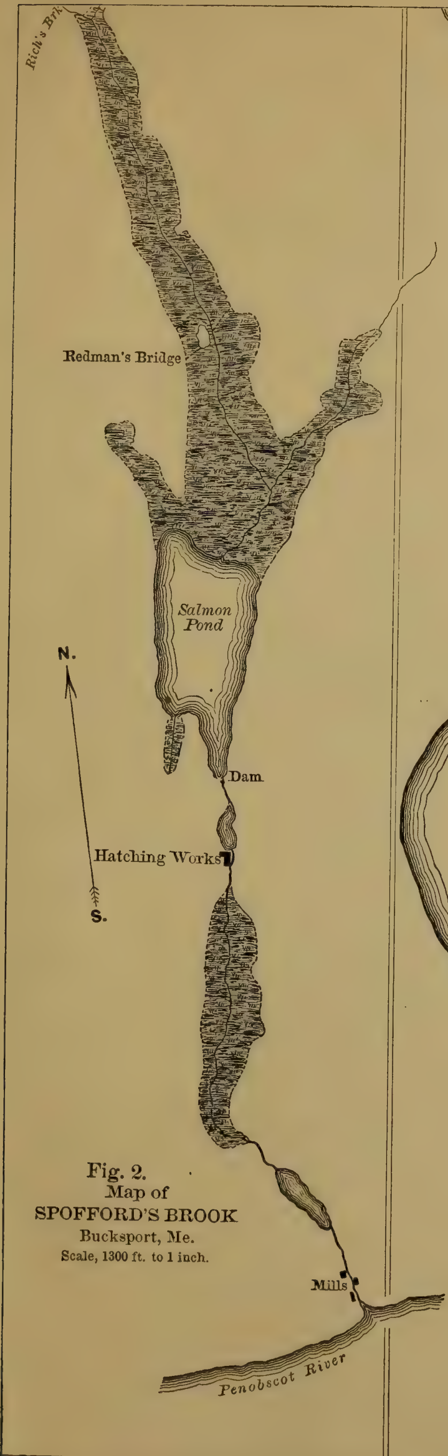


Fig. 2.
Map of
SPOFFORD'S BROOK
Bucksport, Me.
Scale, 1300 ft. to 1 inch.

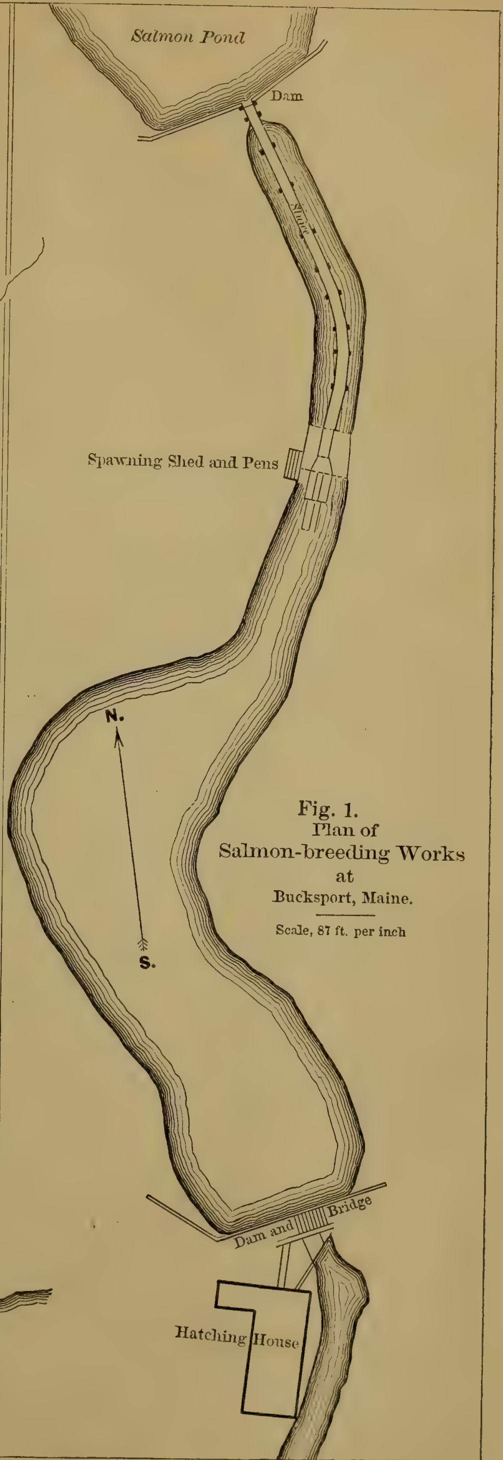


Fig. 1.
Plan of
Salmon-breeding Works
at
Bucksport, Maine.
Scale, 87 ft. per inch

Ground Floor of the
Salmon Hatching House.
Bucksport, Maine.

Scale 20 ft. to an inch.

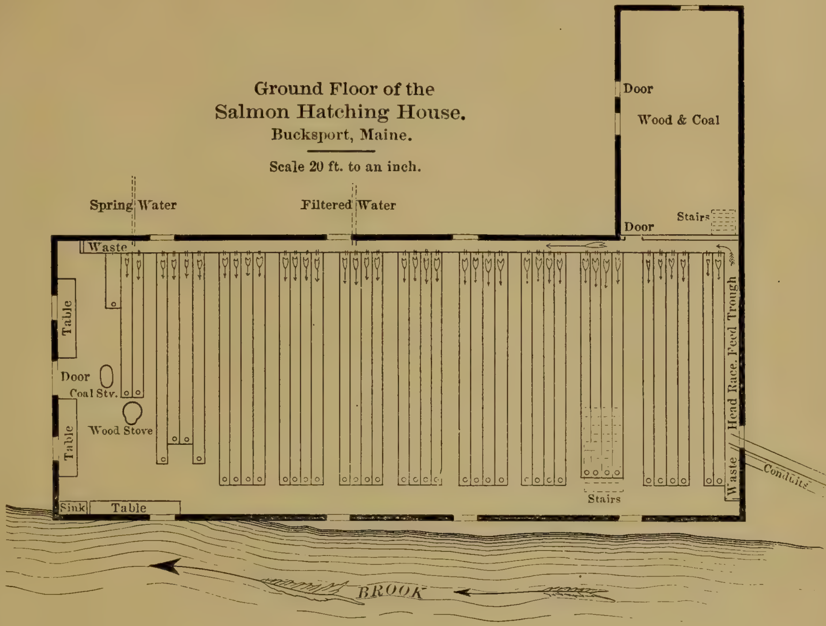


Fig. 1.

Second Floor of the
Salmon Hatching House.
Bucksport, Maine.

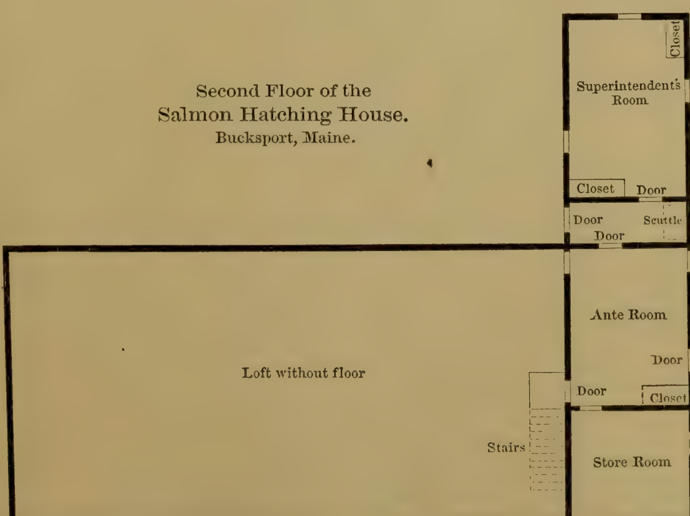
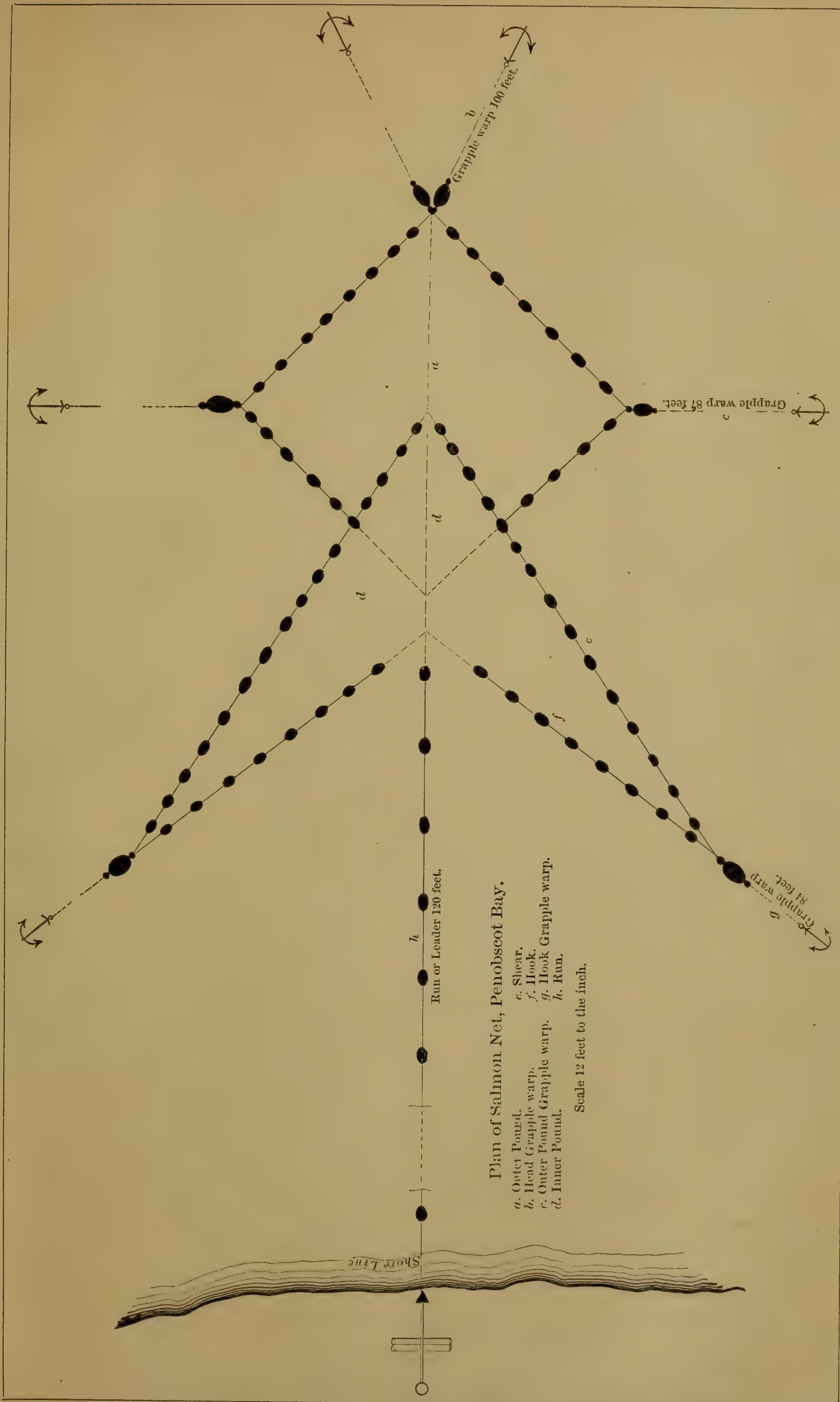


Fig. 2.



Plan of Salmon Net, Penobscot Bay.

a. Outer Pound.
b. Head Grapple warp.
c. Outer Pound Grapple warp.
d. Inner Pound.
e. Shear.
f. Hook.
g. Hook Grapple warp.
h. Run.

Scale 12 feet to the inch.

Plate IX.

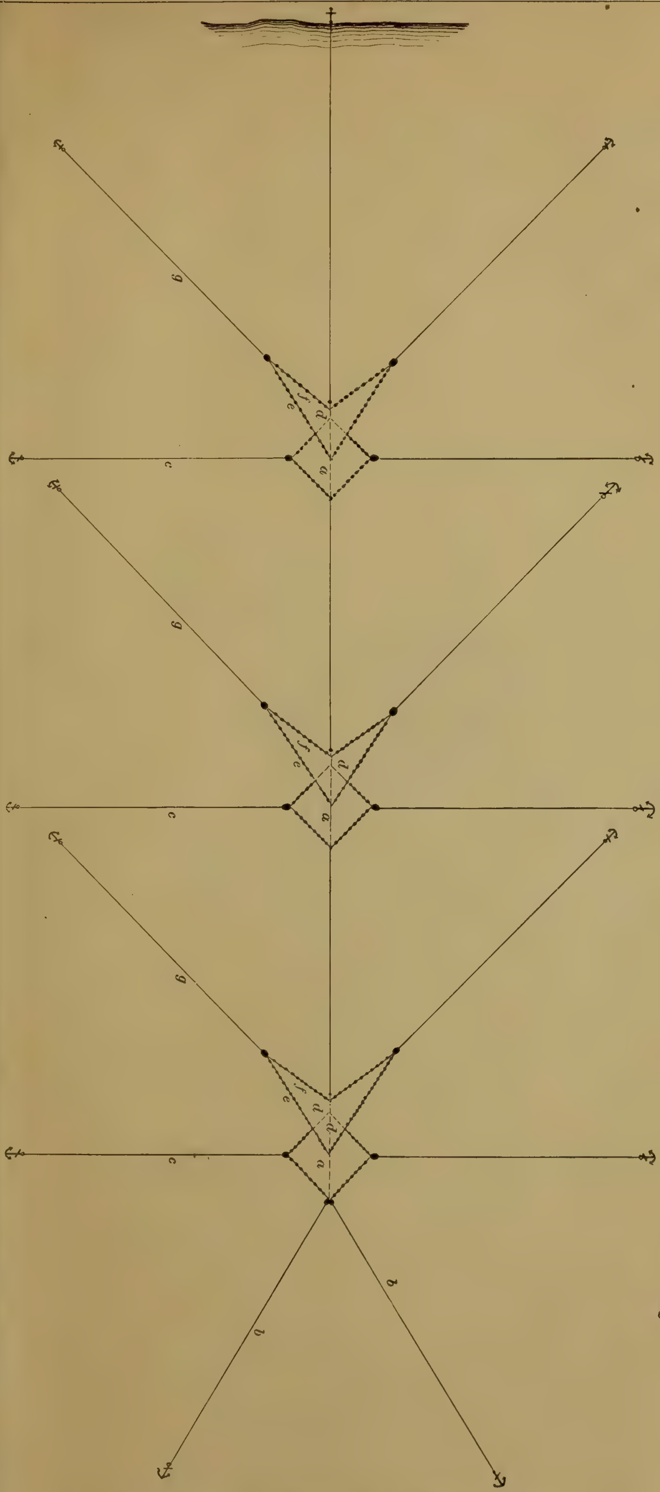


Fig. 1.—Gang of (three) Salmon Nets, Penobscot Bay.

Scale 60 feet to the inch.

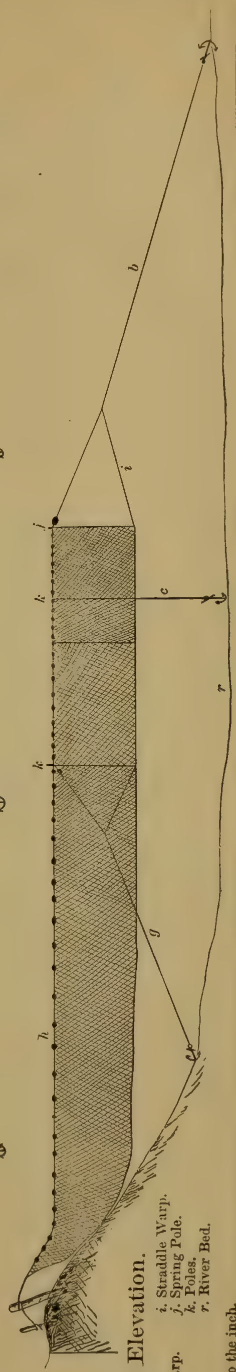
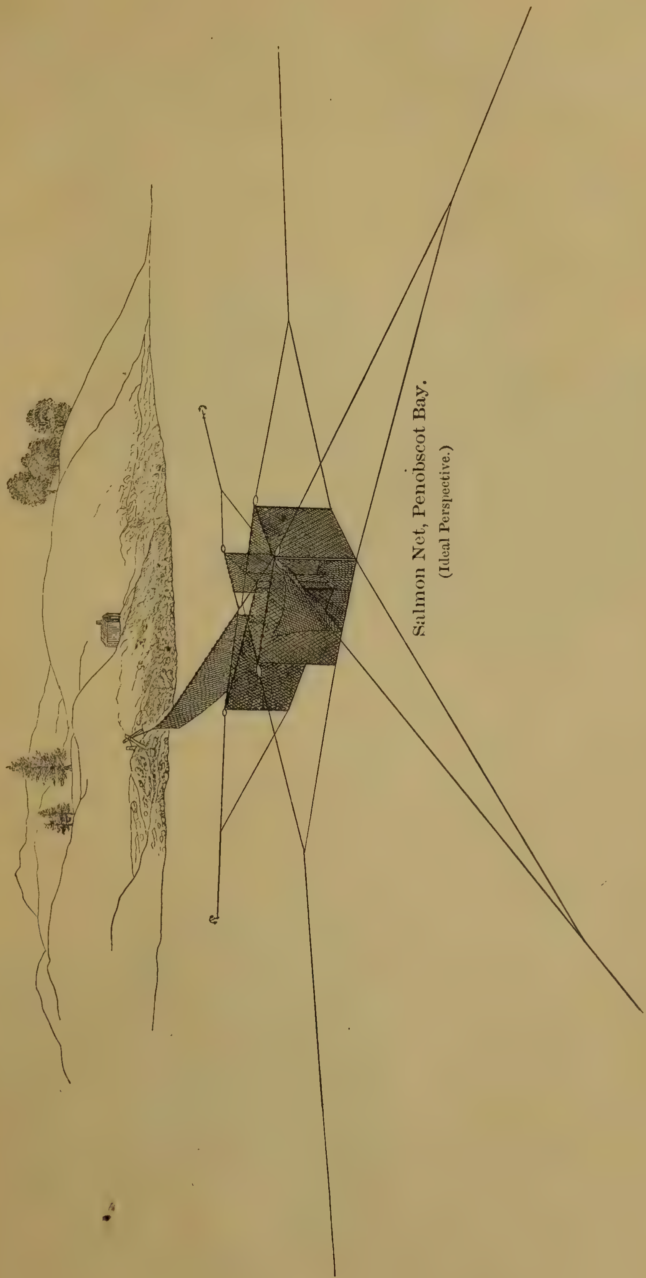


Fig. 2 Side Elevation.

b. Head Grapple Warp.
c. Outer Pound Grapple Warp.
g. Hook Grapple Warp.
h. Run.
i. Straddle Warp.
j. Spring Pole.
k. Poles.
r. River Bed.

Scale 36 feet to the inch.



Salmon Net, Penobscot Bay.

(Ideal Perspective.)

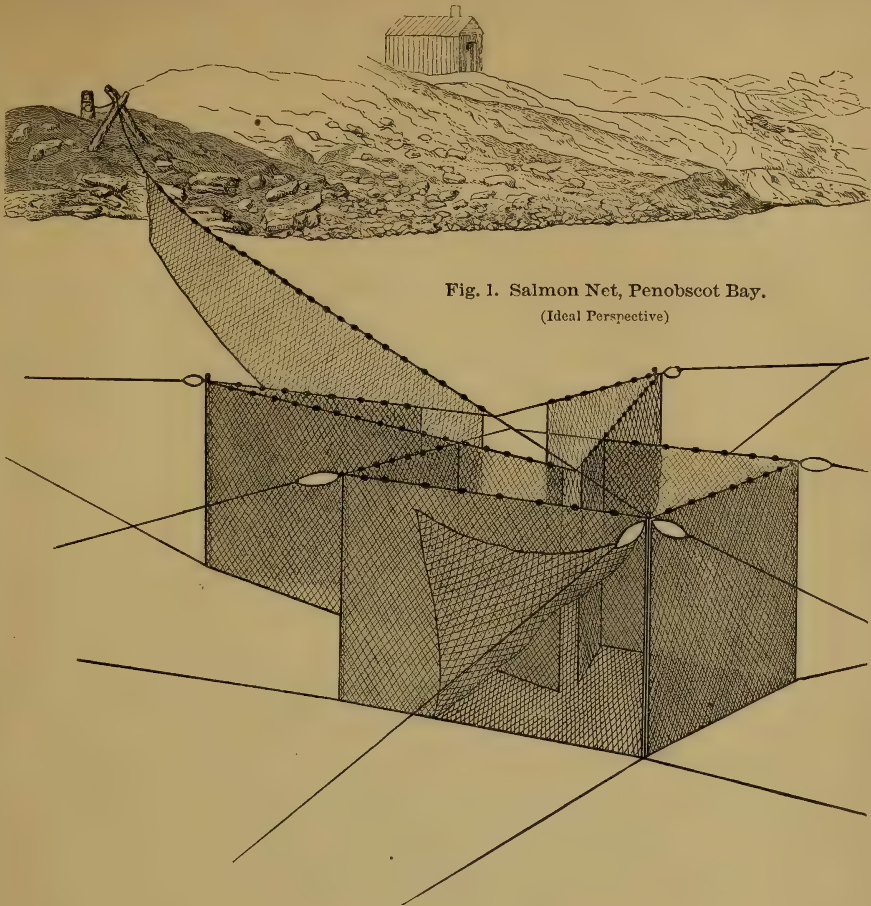


Fig. 1. Salmon Net, Penobscot Bay.
(Ideal Perspective)

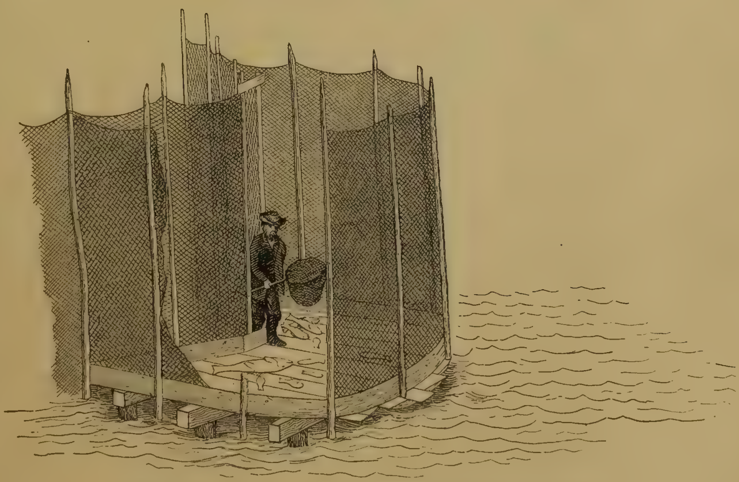


Fig. 2. The Fish-pound of Salmon Weir at Low Water,
Penobscot River.

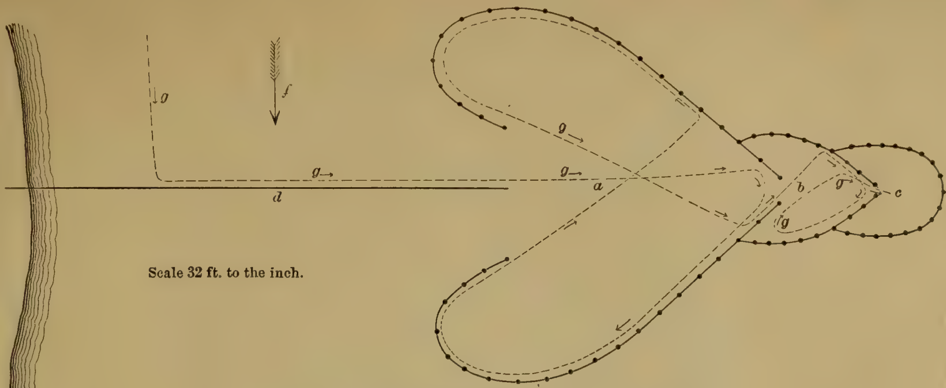
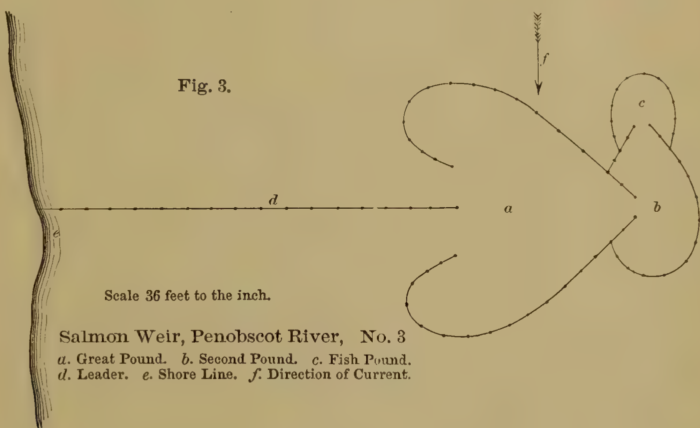


Fig. 1.—Salmon Weir, Penobscot River. No. 1.

a. Great Pound. *b*. Second Pound. *c*. Fish Pound.
d. Leader. *e*. Shore. *f*. Direction of Current.
g.----------------Course of Fish.

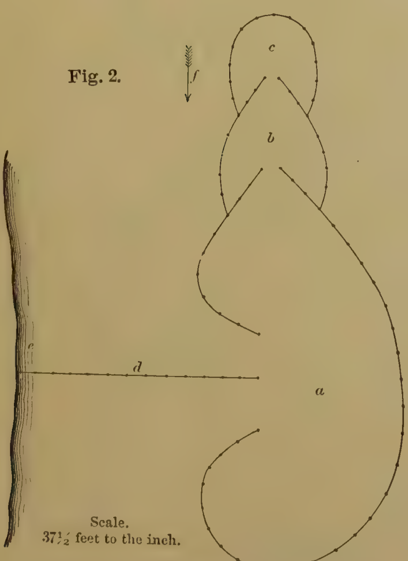
Fig. 3.



Salmon Weir, Penobscot River, No. 3

a. Great Pound. *b*. Second Pound. *c*. Fish Pound.
d. Leader. *e*. Shore Line. *f*. Direction of Current.

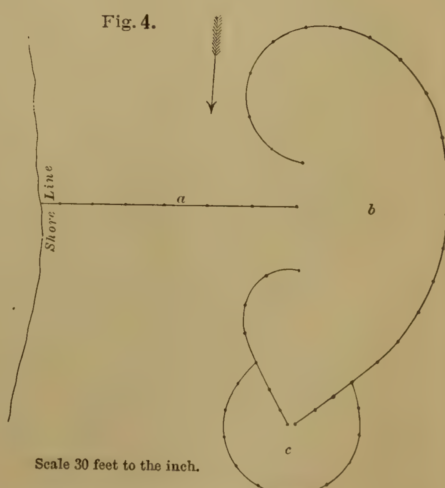
Fig. 2.



Salmon Weir, Penobscot River, No. 2

a. Great Pound. *b*. Second Pound. *c*. Fish Pound
d. Leader. *e*. Shore. *f*. Direction of Current.

Fig. 4.



Fish Weir, St. Croix River.

a. Hedge. *b*. Big Pound *c*. Little Pound.

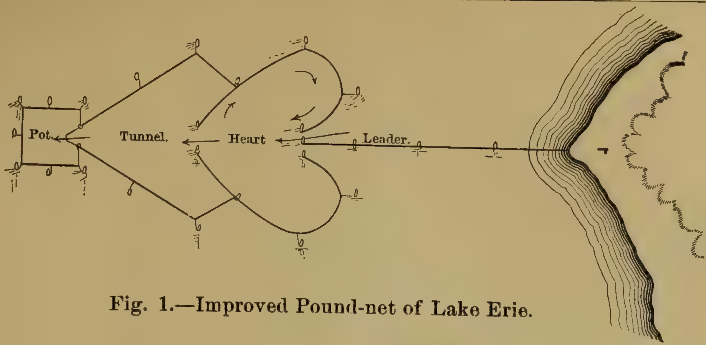


Fig. 1.—Improved Pound-net of Lake Erie.

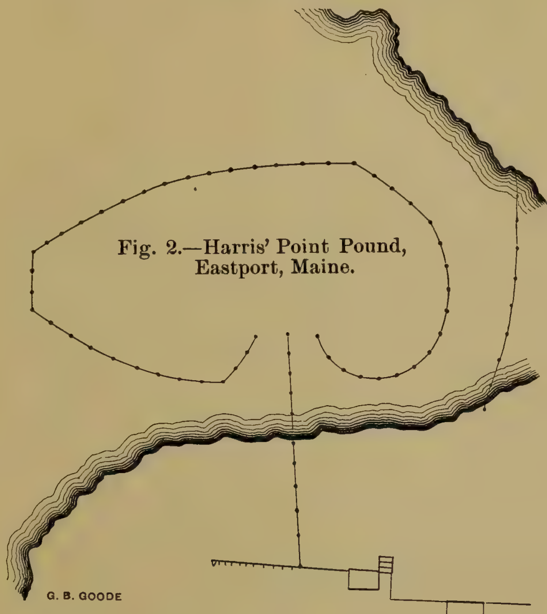


Fig. 2.—Harris' Point Pound, Eastport, Maine.

Fig. 3.—Herring Weir, near Eastport, Me.

Fig. 1

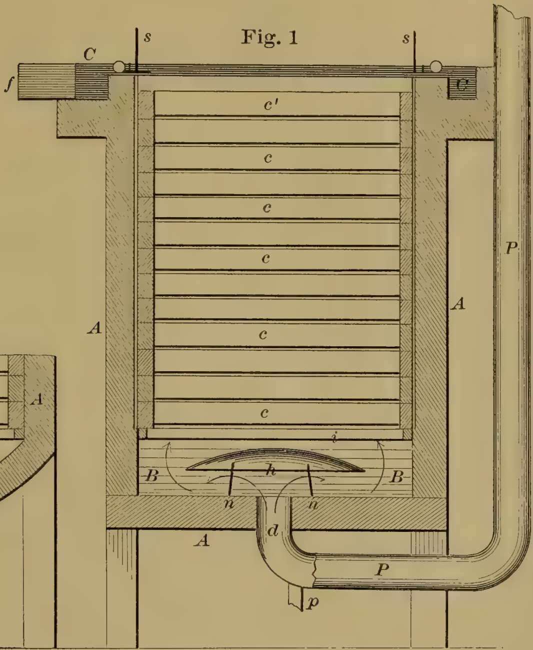


Fig. 3

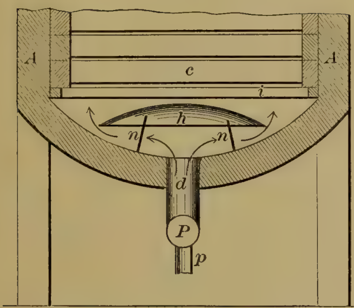
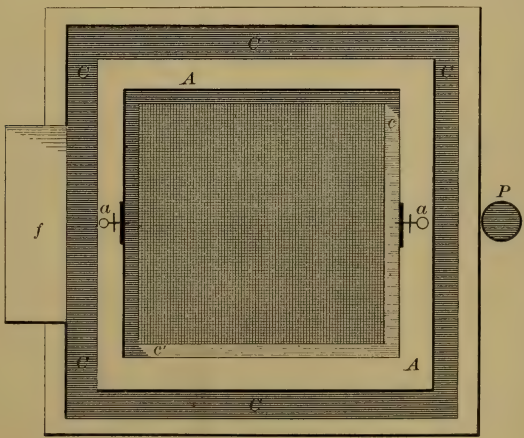


Fig. 2



M. G. HOLTON.
FISH SPAWN-HATCHERS.
Patented March 18, 1873.
No. 136,834.

Fig. 1

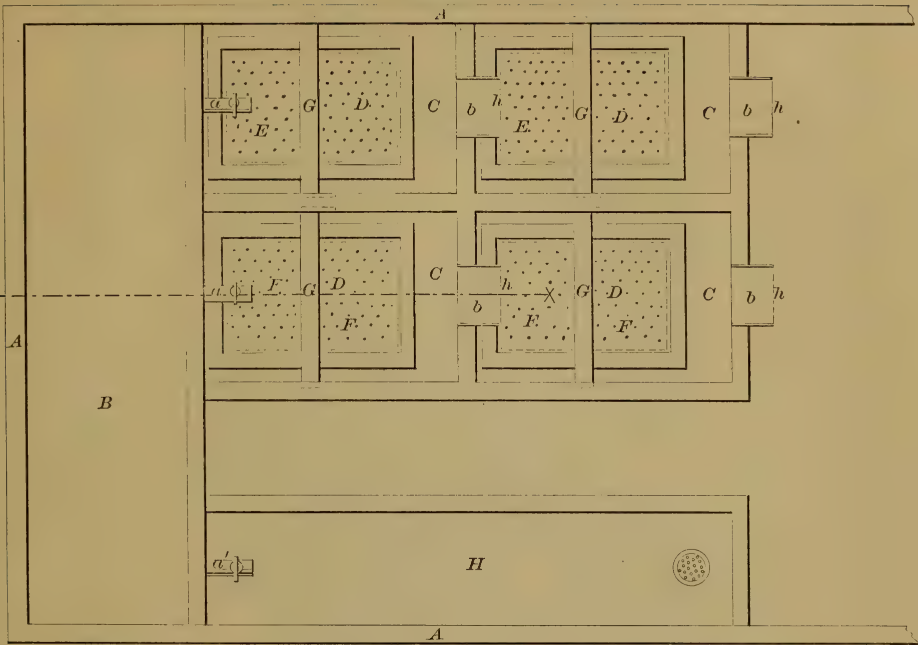


Fig. 3

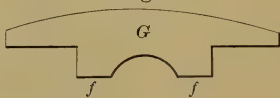
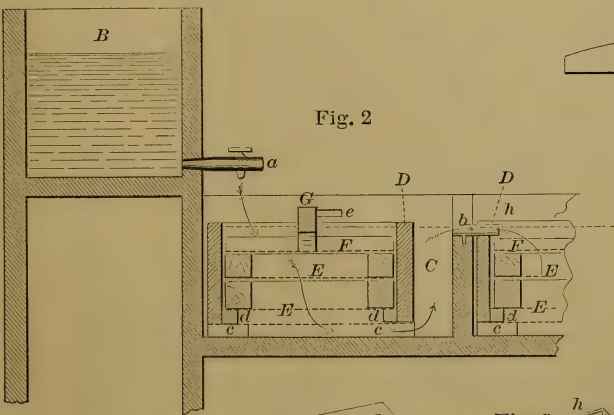


Fig. 2



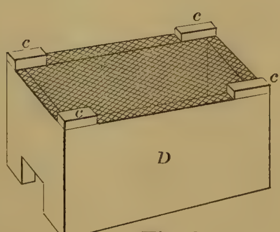


Fig. 6

Fig. 5

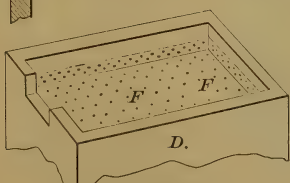
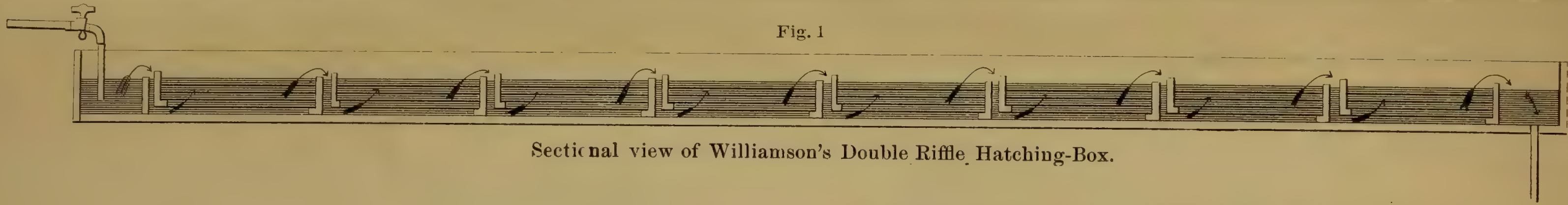


Fig. 4

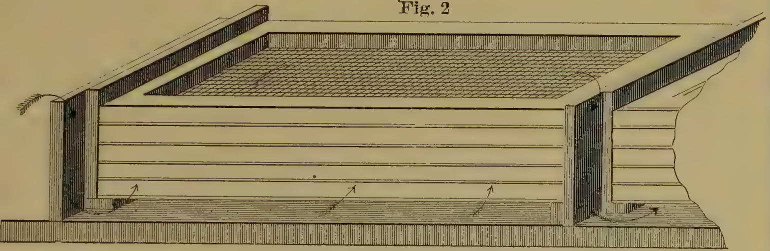
N. W. CLARK.
FISH-HATCHING APPARATUS.
Patented March 3, 1874.
No. 148,035.

Fig. 1



Sectional view of Williamson's Double Riffle Hatching-Box.

Fig. 2



Nest of trays in Williamson's Double Riffle Hatching-Box.

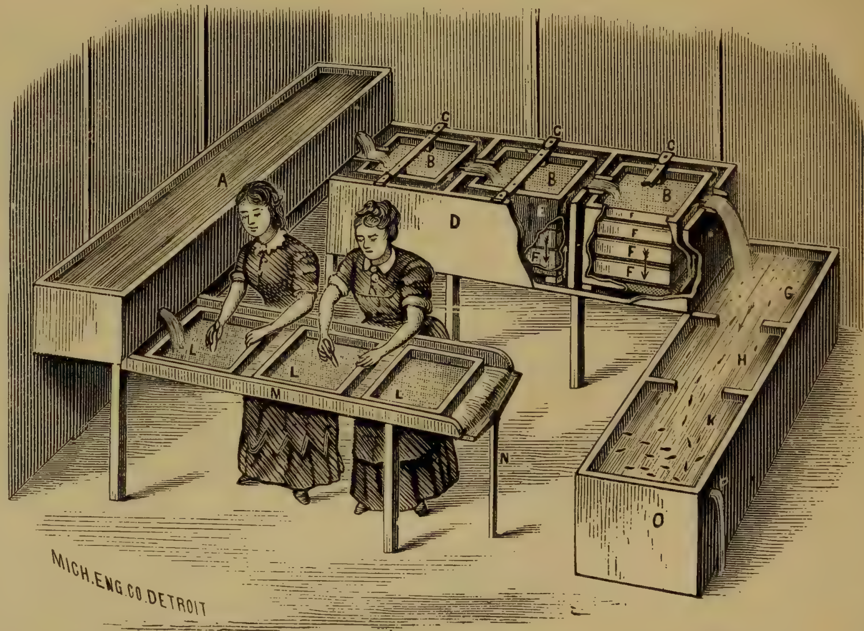


Fig. 3.—Perspective view of Clarke's Hatching-apparatus in operation.

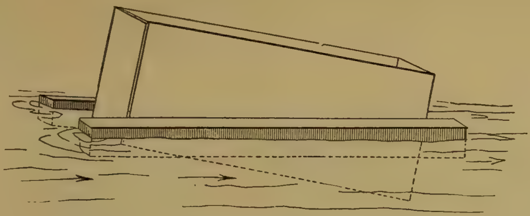


Fig. 1.—Seth Green's Hatching Box.

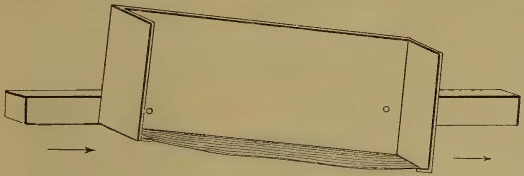


Fig. 2.—Vertical section of the same.

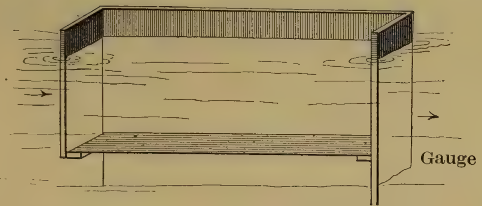


Fig. 3. Vertical section of Hatching Box of H. M. Bannister.

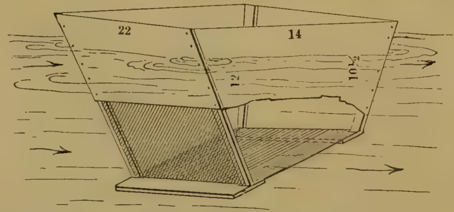


Fig. 4.—Stilwell and Atkin's Shad Box.

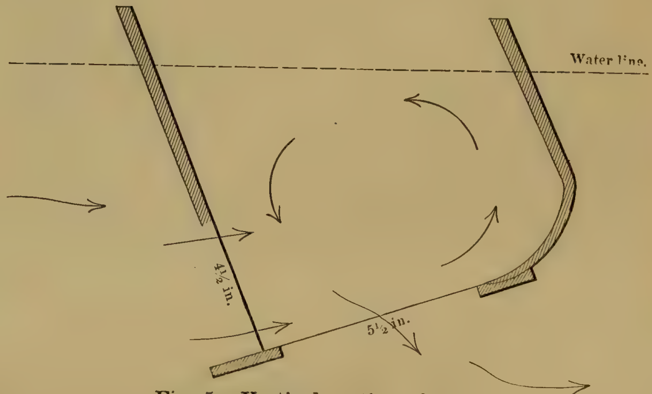


Fig. 5.—Vertical section of same.

Fig. 1

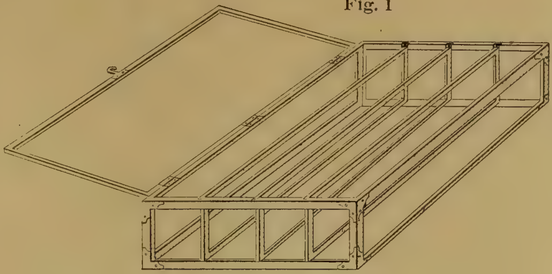


Fig. 2.

Fig. 1.—Perspective view of frame of box containing frames of gauze screens.
Fig. 2.—Plan view of box.
Fig. 3.—Plan view of gauze screens.
Fig. 4.—Perspective view of shallow pan containing gauze screen.
Fig. 5.—Skeleton of hatching basket.
Fig. 6.—Hatching basket.

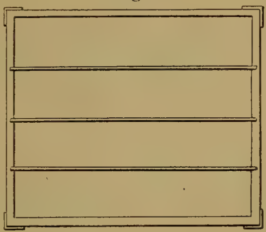


Fig. 3.

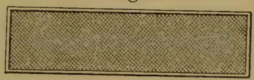


Fig. 4.

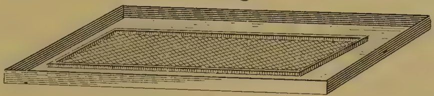


Fig. 5

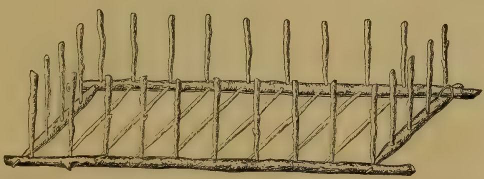
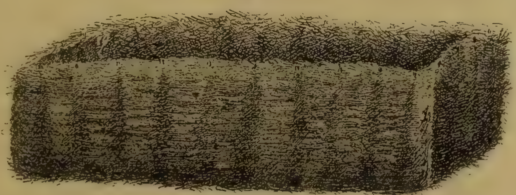


Fig. 6.



Illustrations to Paper by R. Hessel on mode of hatching adhesive eggs.

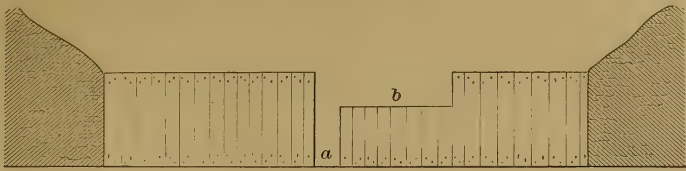


Fig. 1

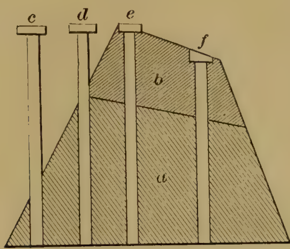


Fig. 2

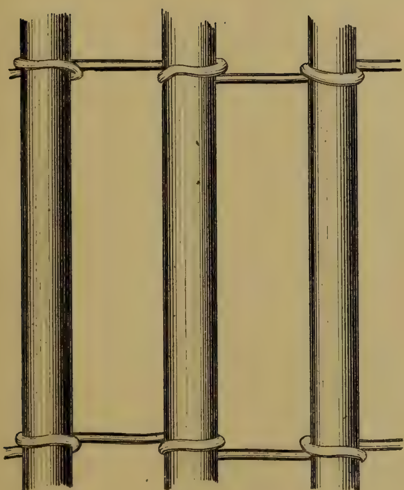


Fig. 4

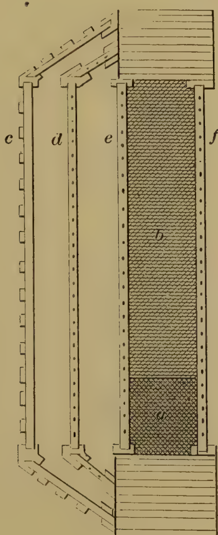


Fig. 3

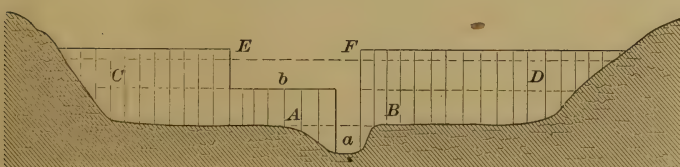


Fig. 5

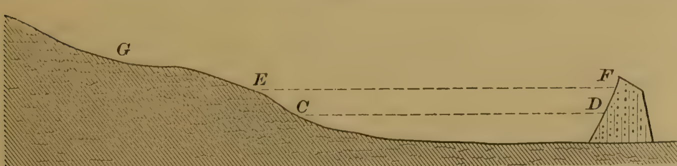


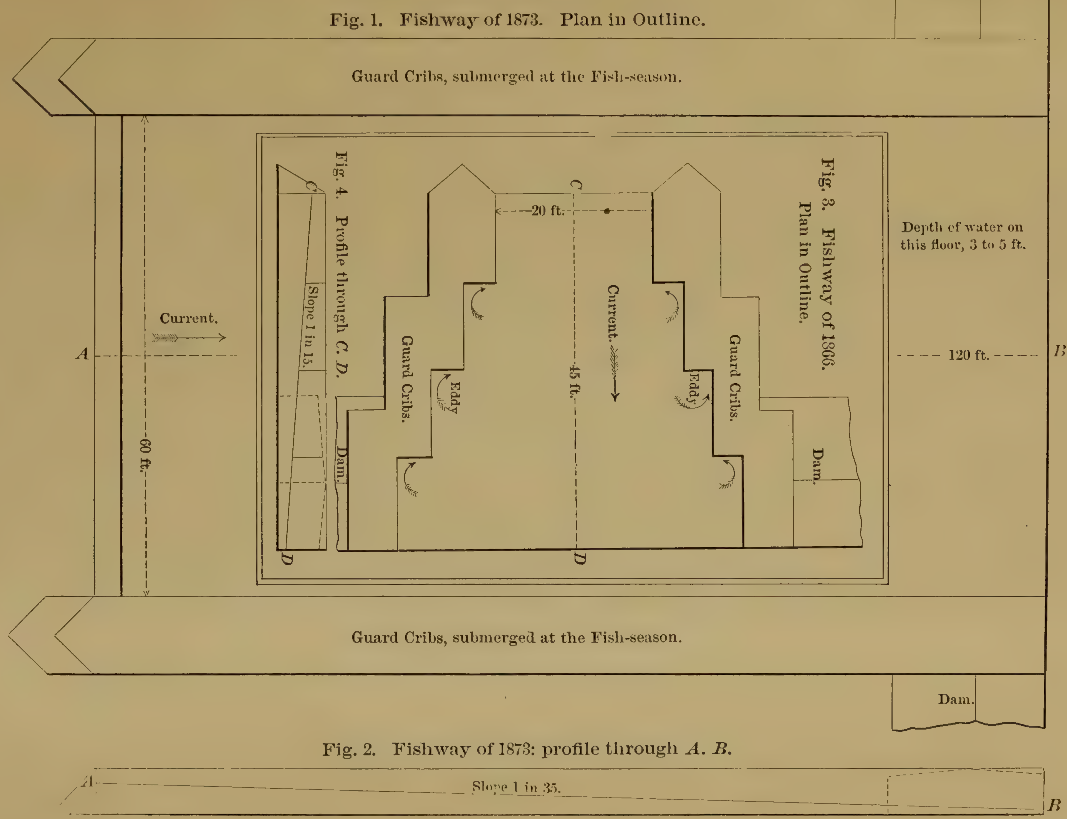
Fig. 6

Illustrations to accompany paper by Theodore Lyman on Fish Culture in brackish waters.

Fishways in the Columbia Dam, Susquehanna River, Pennsylvania.

(Intended mainly for the passage of Shad.)

Scale, 24 ft.=1 inch.



Inclined Fishways.

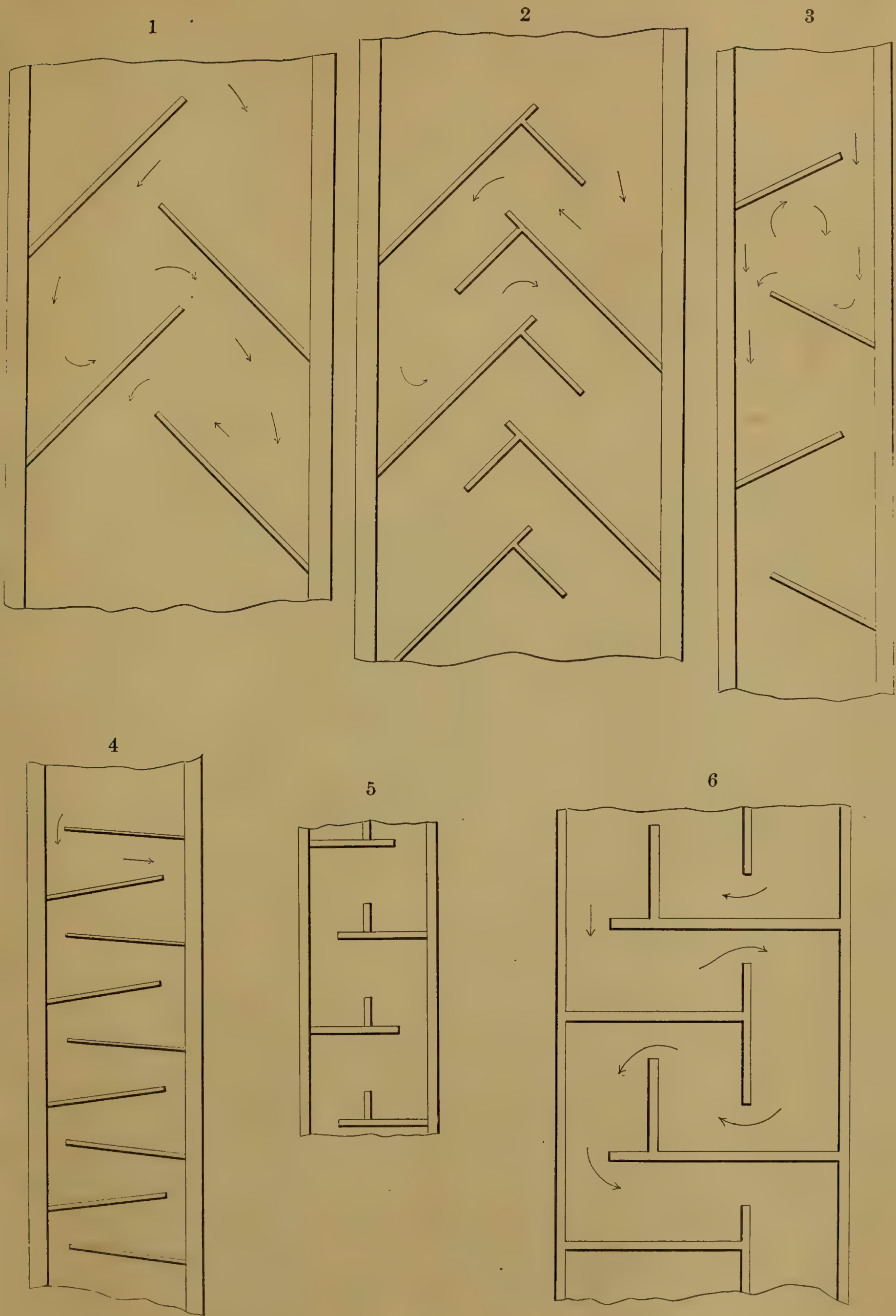


Fig. 1. The Swazey Plan, invented by Alfred Swazey of Bucksport, Maine.
2. The same, with additions, by C. G. Atkins.
3. The Foster Plan.

Fig. 4. Same, modified; as built on Penmaquan River.
5. From a design for a fishway on Androscoggin River, Aug. 1870.
6. The Brackett plan, patented by E. A. Brackett of Massachusetts.

Plate XXII.

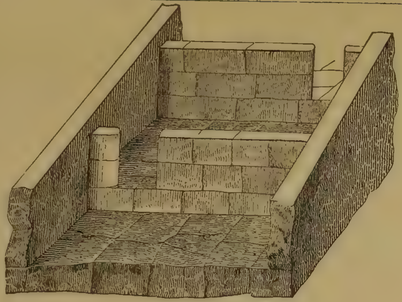


Fig. 1.
Smith's Fishway; invented by James Smith of Deanstone, Scotland, 1840.

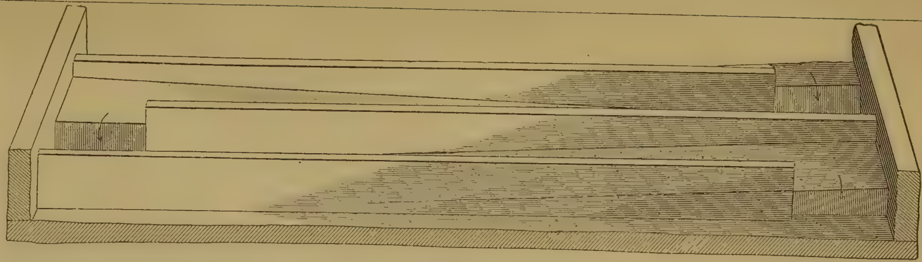


Fig. 2.
Steck's Fishway; invented by Daniel Steck of Pennsylvania.

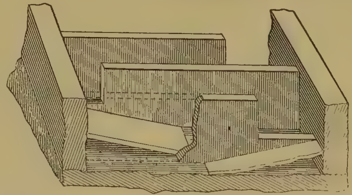
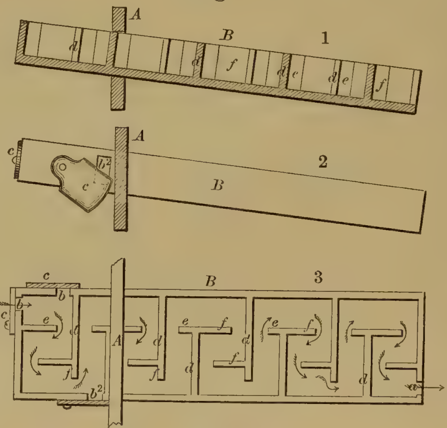


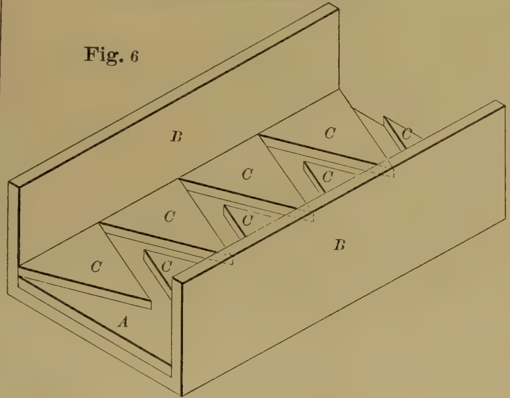
Fig. 3.
A recent device, not tested.

Fig. 5



E. A. BRACKETT.
Improvement in Fish-Ways.
Patented Oct. 22, 1872.
No. 132,349.

Fig. 6



JAMES D. BREWER.
Improvement in Chute and Fishway.
Patented April 30, 1872.
No. 126,257.

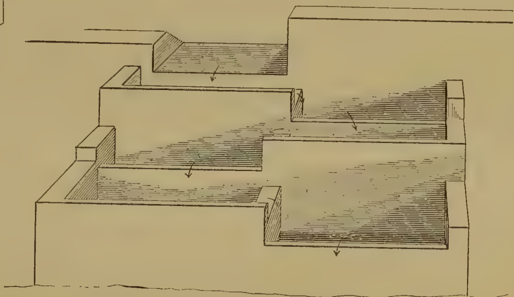
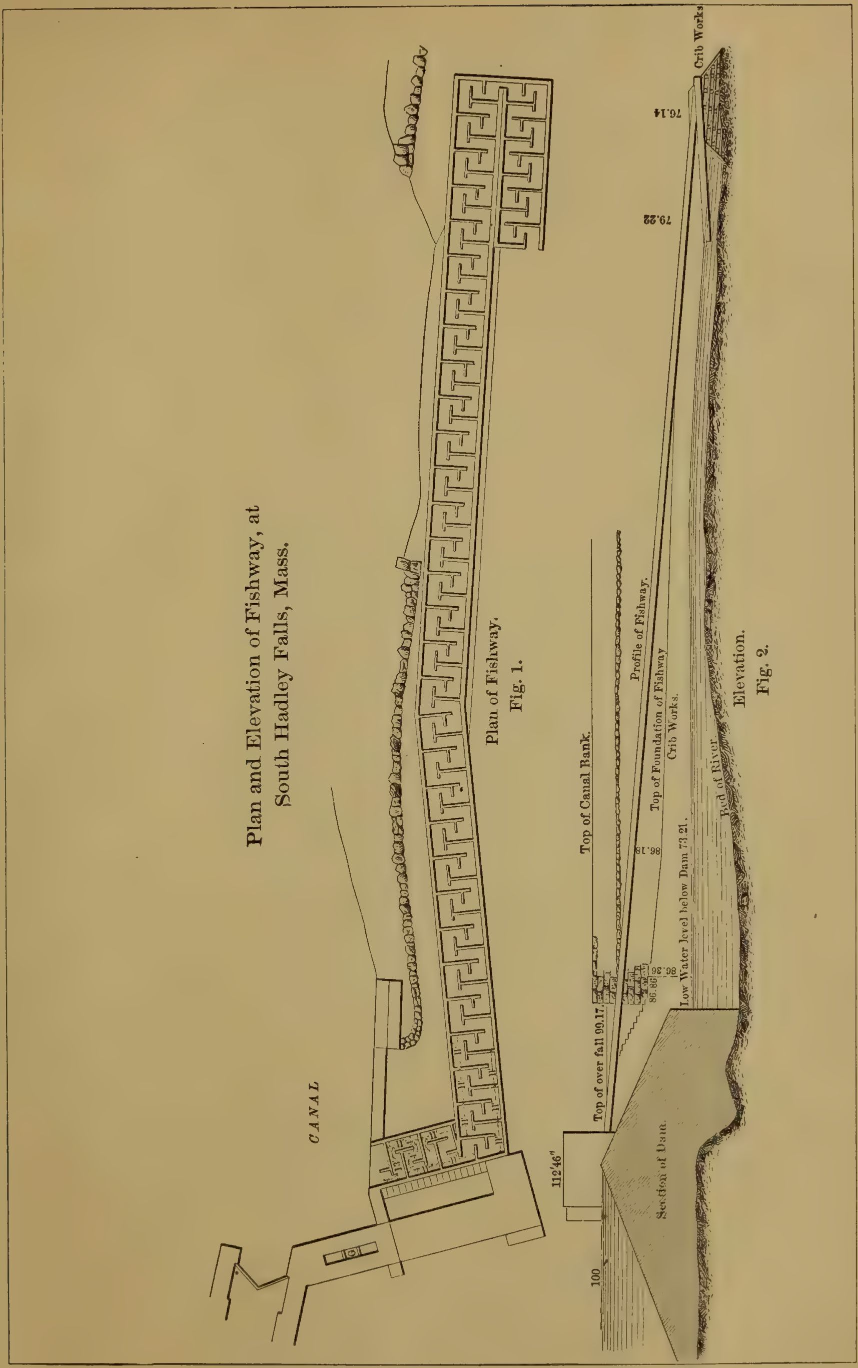


Fig. 4. The Pool Fishway.

Plate XXIII.



Plan and Elevation of Fishway, at South Hadley Falls, Mass.

Plate XXIV.

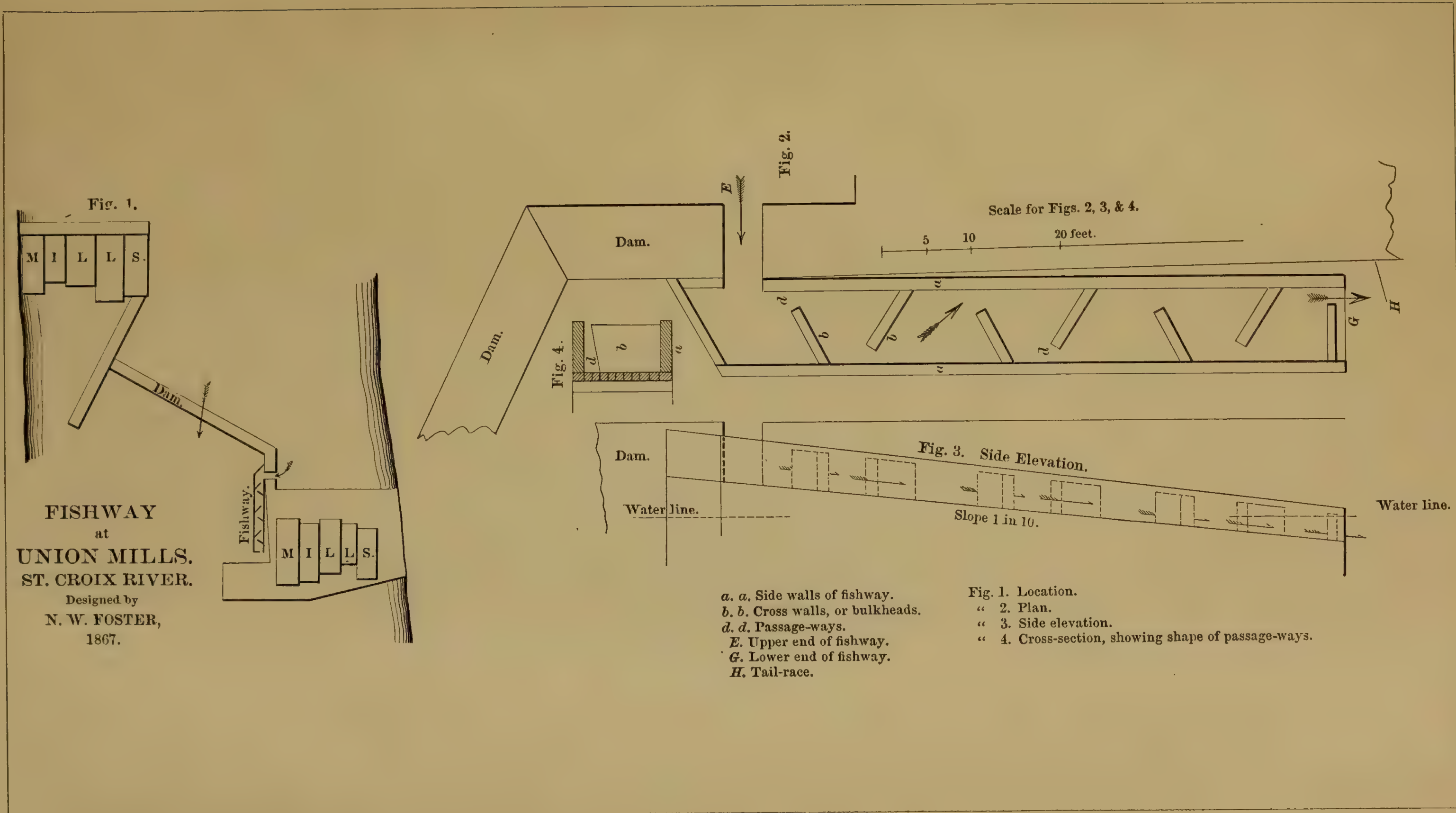

FISHWAY
at
UNION MILLS.
ST. CROIX RIVER.
Designed by
N. W. FOSTER,
1867.
Fig. 1.
MILLS.
Dam.
Fishway.
Fig. 2.
Fig. 3. Side Elevation.
Fig. 4.
Scale for Figs. 2, 3, & 4.
5
10
20 feet.
Dam.
E
G
H
Water line.
Slope 1 in 10.
a. a. Side walls of fishway.
b. b. Cross walls, or bulkheads.
d. d. Passage-ways.
E. Upper end of fishway.
G. Lower end of fishway.
H. Tail-race.
Fig. 1. Location.
" 2. Plan.
" 3. Side elevation.
" 4. Cross-section, showing shape of passage-ways.

Plate XXV.

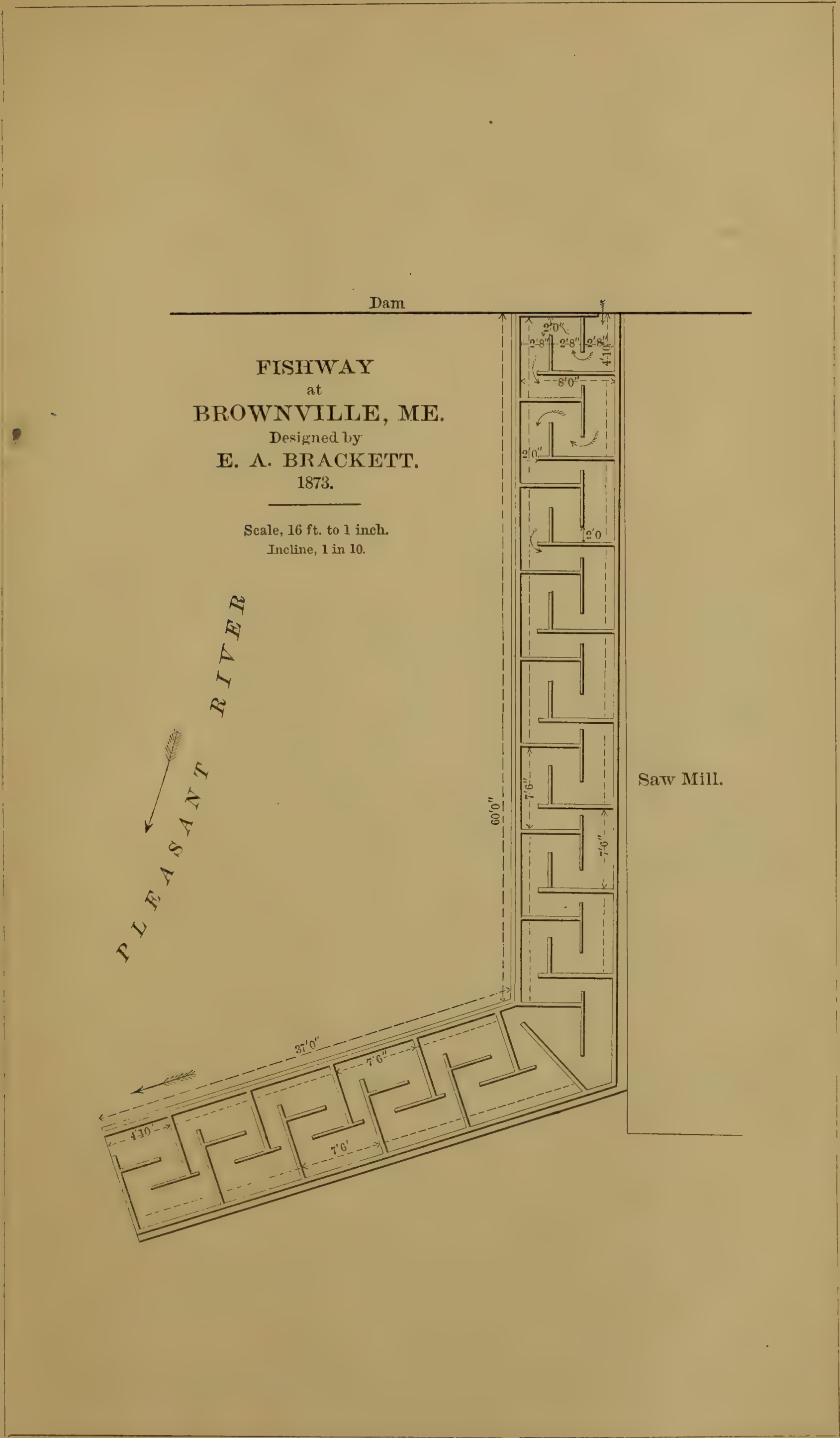
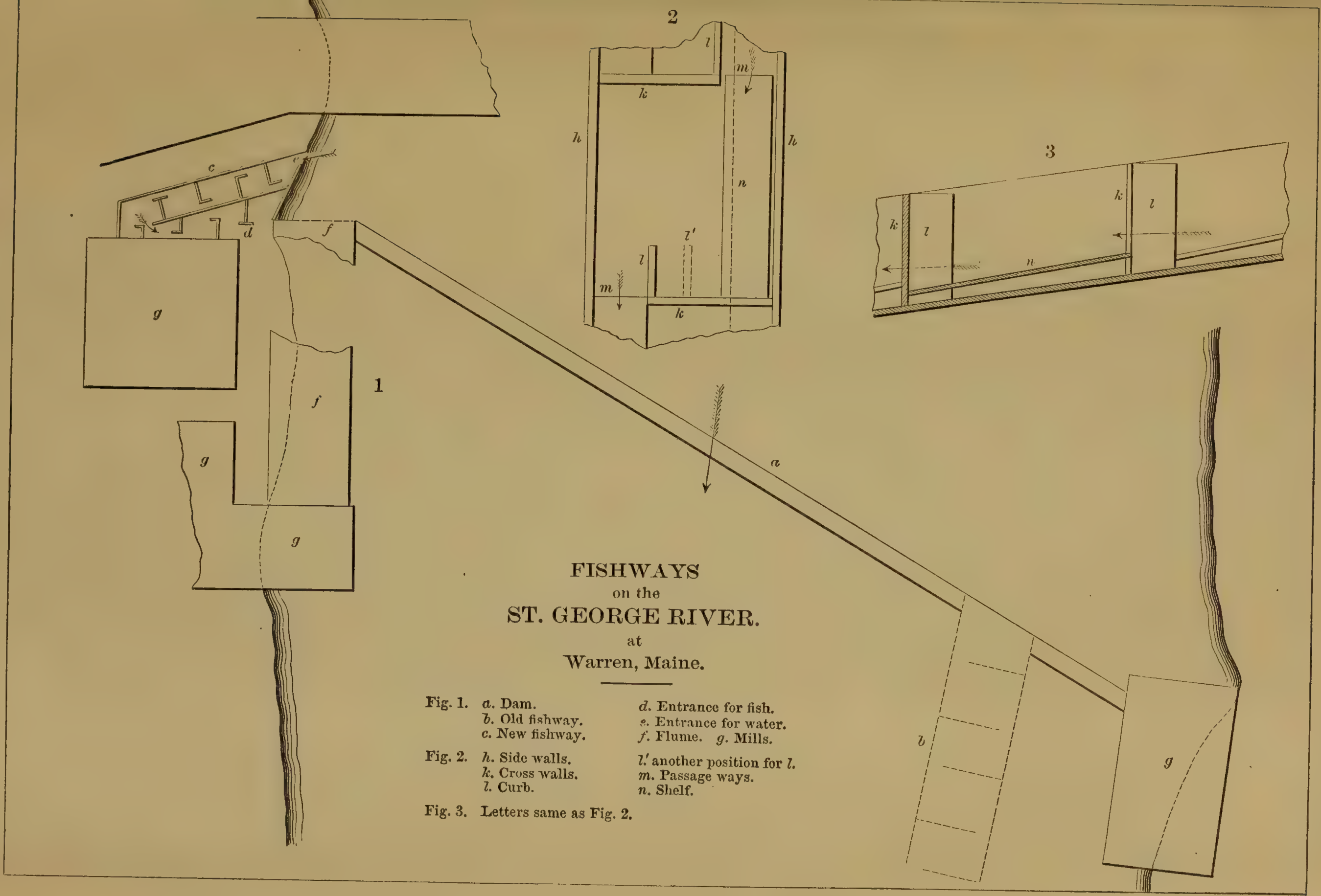

Dam
FISHWAY
at
BROWNVILLE, ME.
Designed by
E. A. BRACKETT.
1873.
Scale, 16 ft. to 1 inch.
Incline, 1 in 10.
PLEASANT RIVER
Saw Mill.
2'0"
2'8"
2'8"
2'8"
4'10"
8'0"
2'0"
2'0
7'6"
7'6"
60'0"
37'0"
7'6"
7'6'
4'10"

Plate XXVI.



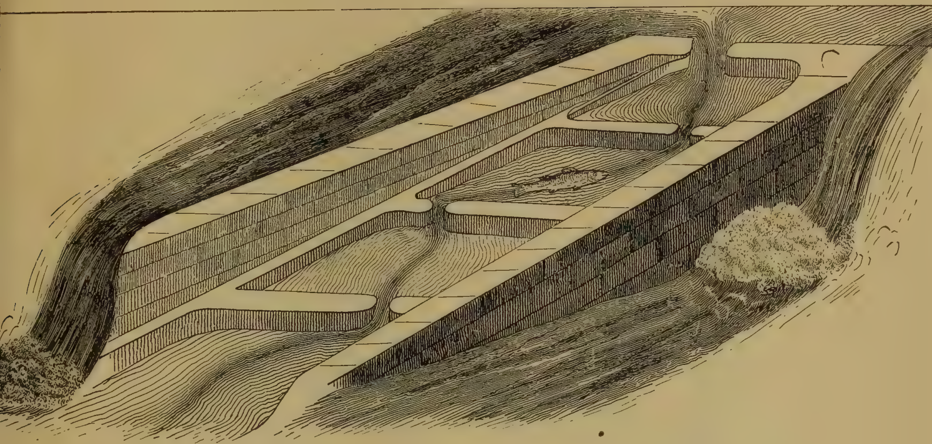
FISHWAYS
on the
ST. GEORGE RIVER.
at
Warren, Maine.

Fig. 1. *a.* Dam. *b.* Old fishway. *c.* New fishway. *d.* Entrance for fish. *e.* Entrance for water. *f.* Flume. *g.* Mills.

Fig. 2. *h.* Side walls. *k.* Cross walls. *l.* Curb. *l'.* another position for *l.* *m.* Passage ways. *n.* Shelf.

Fig. 3. Letters same as Fig. 2.

Fig. 1.



Smith's Salmon Ladder, 1840.

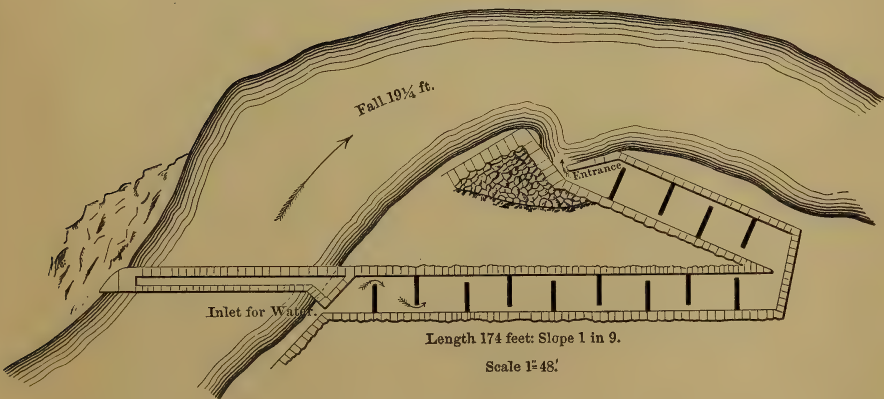
Gradient one in seven. Inlet 2 feet wide and 2 feet deep, opening between each pool 1 foot wide. Water in each pool 15 inches deep.

Fig. 2.

Fishway (for salmon) at Balisodare, Ireland.

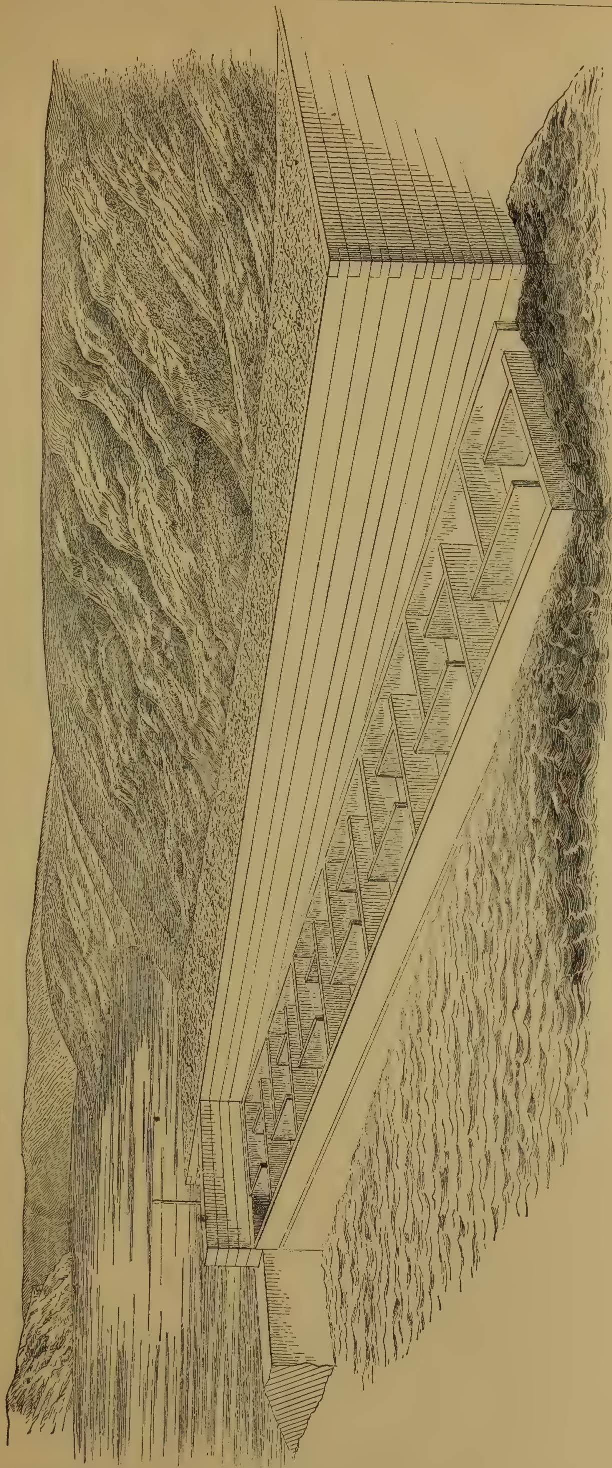
(After Roberts.)

[Inclined Plane; gradient 1 in 9.]



Length 174 feet: Slope 1 in 9.

Scale 1" = 48.'



Brackett's Fishway, closed; perspective view.

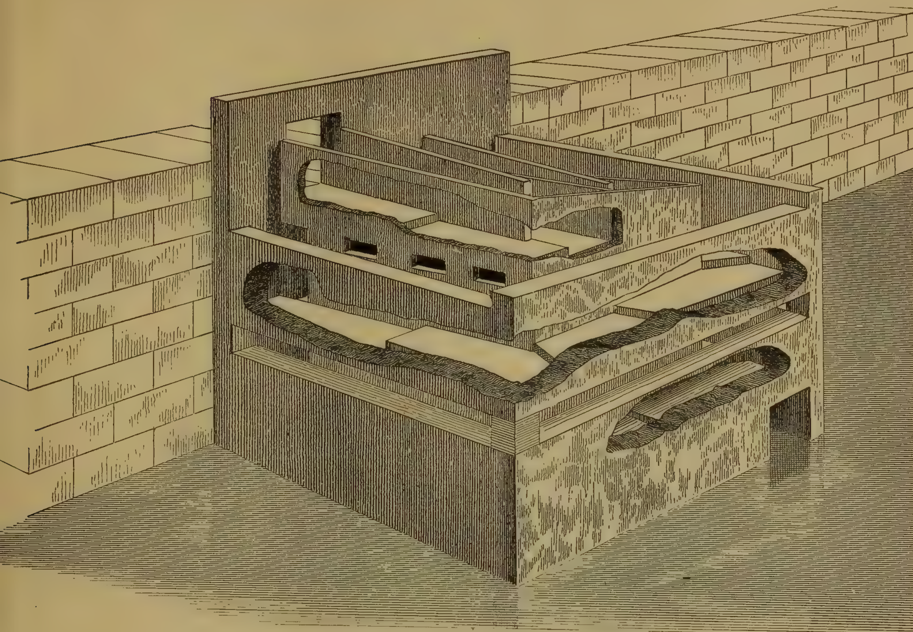
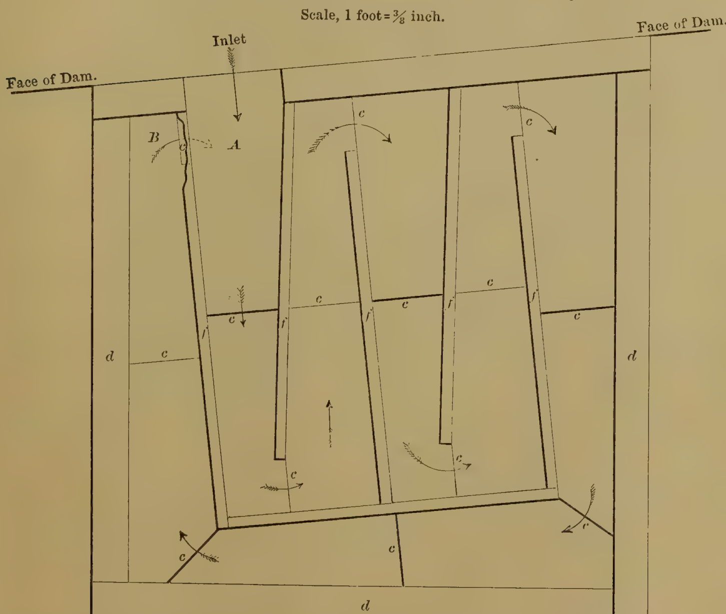


Fig. 1.—Perspective View of Pike's Fishway.

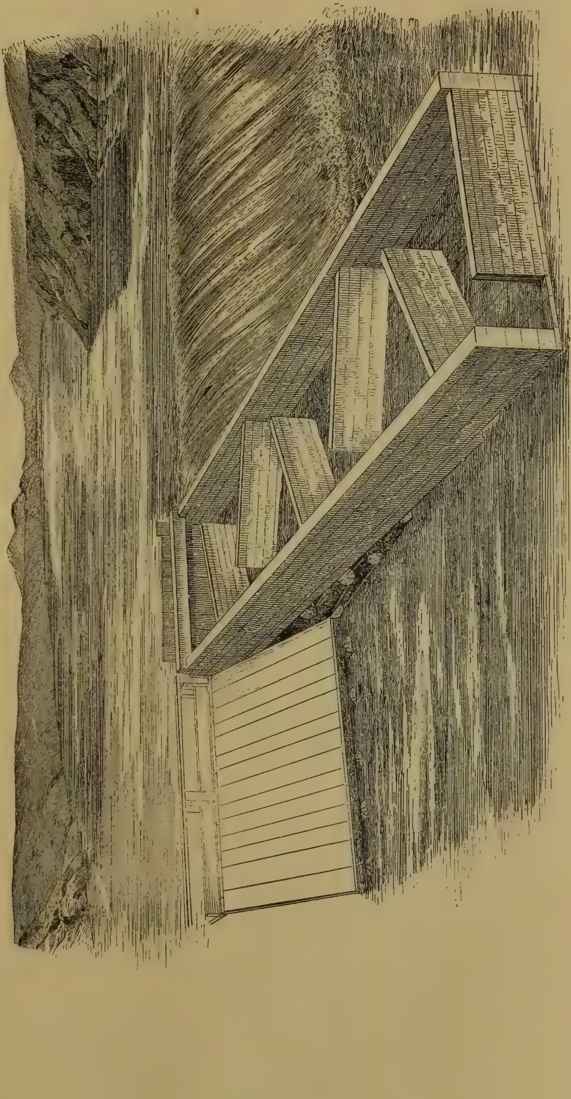
Fig. 2.—Ground-plan of Pike's Fishway.

Scale, 1 foot = 3/8 inch.



Arrows show the direction of the current: *A*. beginning of circuit. *B*. end of circuit.
d, *d*, *d*. Outside walls: *f*. Partition walls: *c*, *c*, *&c*. Steps, 3 inches each, the floor between the steps being level.
When the water reaches *B*, it has accomplished a distance of 75 feet, and has fallen 39 inches.
By another step of 3 inches it passes under *A* and begins a new circuit.

Plate XXX.



Foster's Fishway (closed.)

Common Rectangular Fishway, in operation.

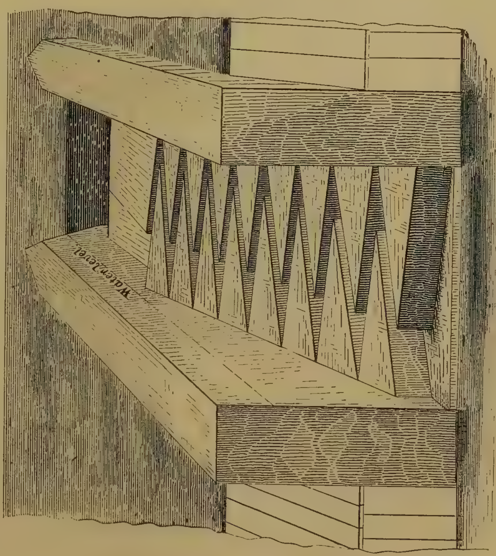


Fig. 1. Brewer's First Fishway.

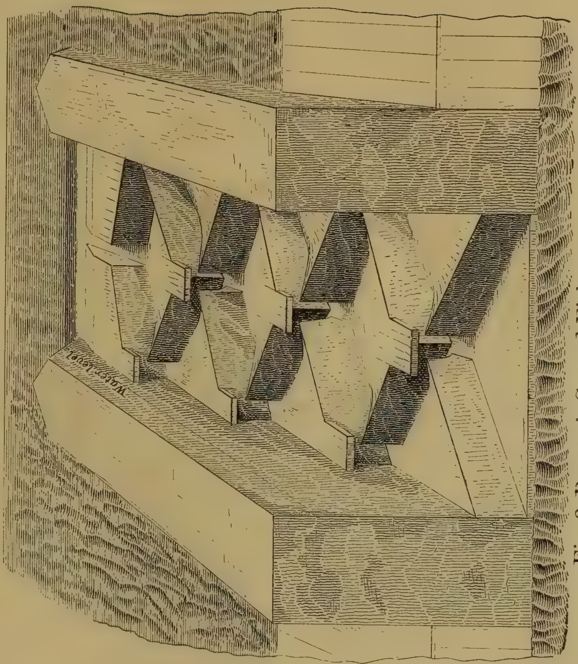
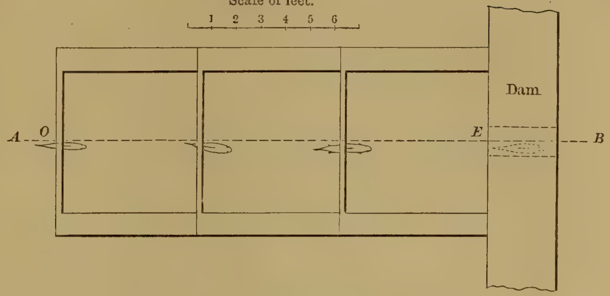


Fig. 2. Brewer's Second Fishway.

Fig. 1. Cail's Straight Fishway.

1.—Plan.

Scale of feet.



2.—Section through *A. B.*

Scale of feet.

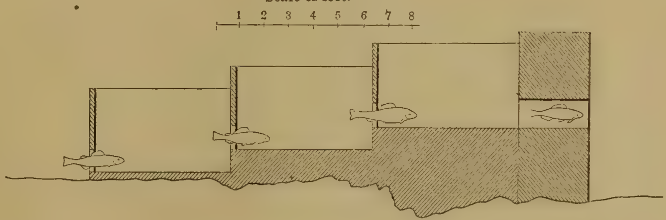
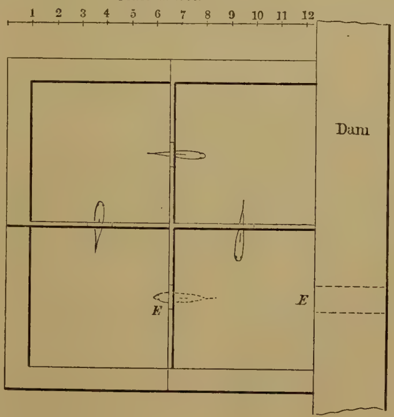


Fig. 2. Cail's Spiral Fishway.

Scale of feet.



Atkins' Fishway.

Fig. 1. Plan.

Scale of feet.

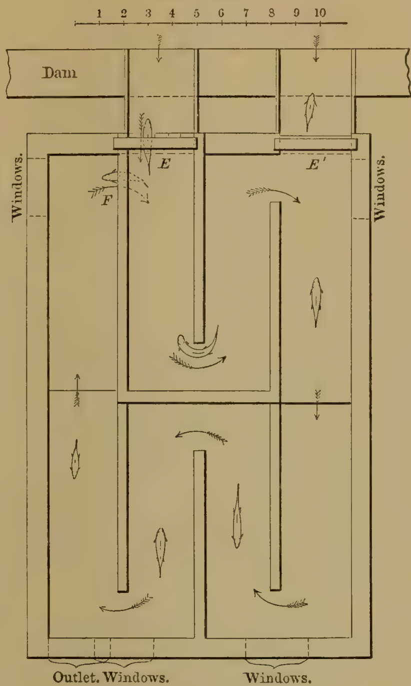
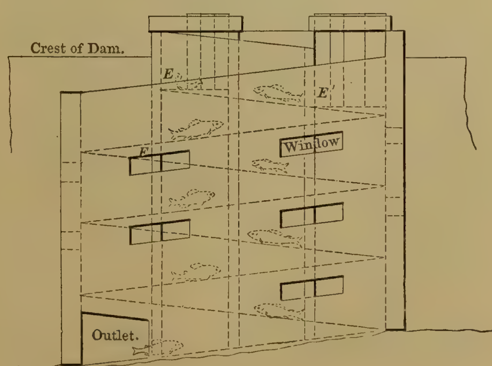
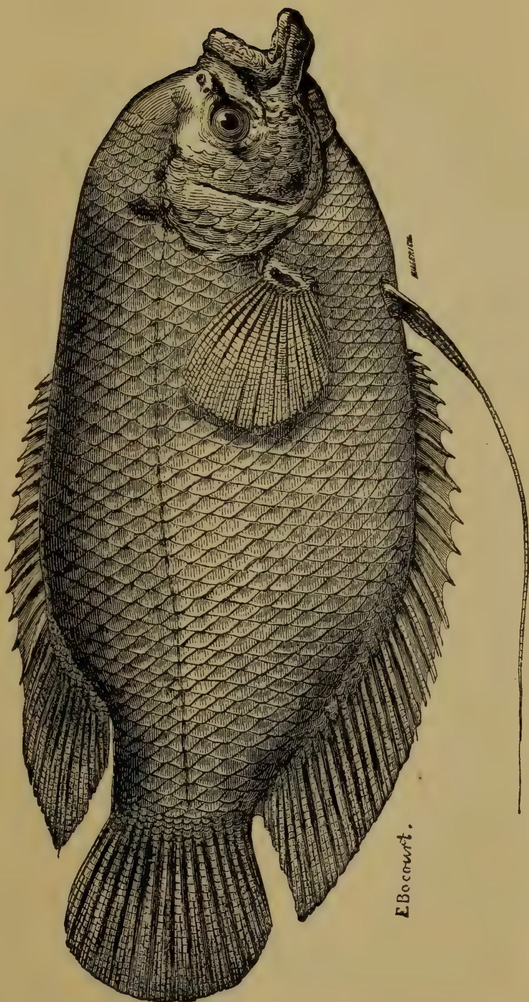


Fig. 2. Elevation.





Osphromenus goramy; old, without bands and with gibbous forehead.

Fig. 1.

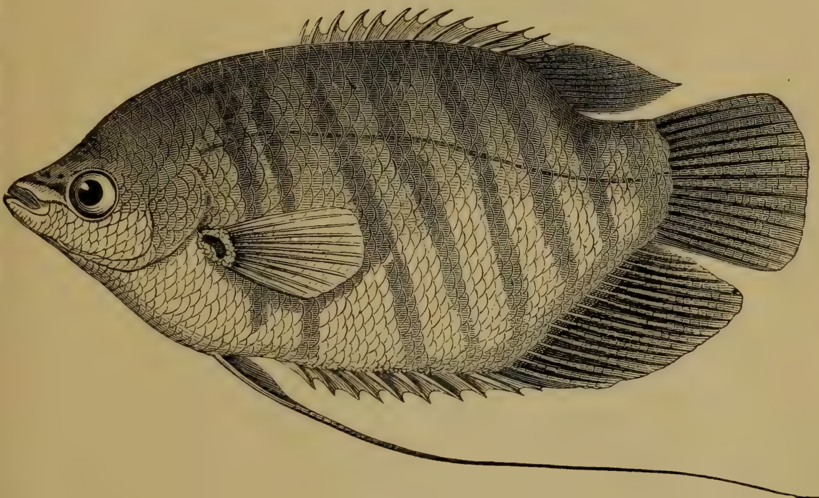


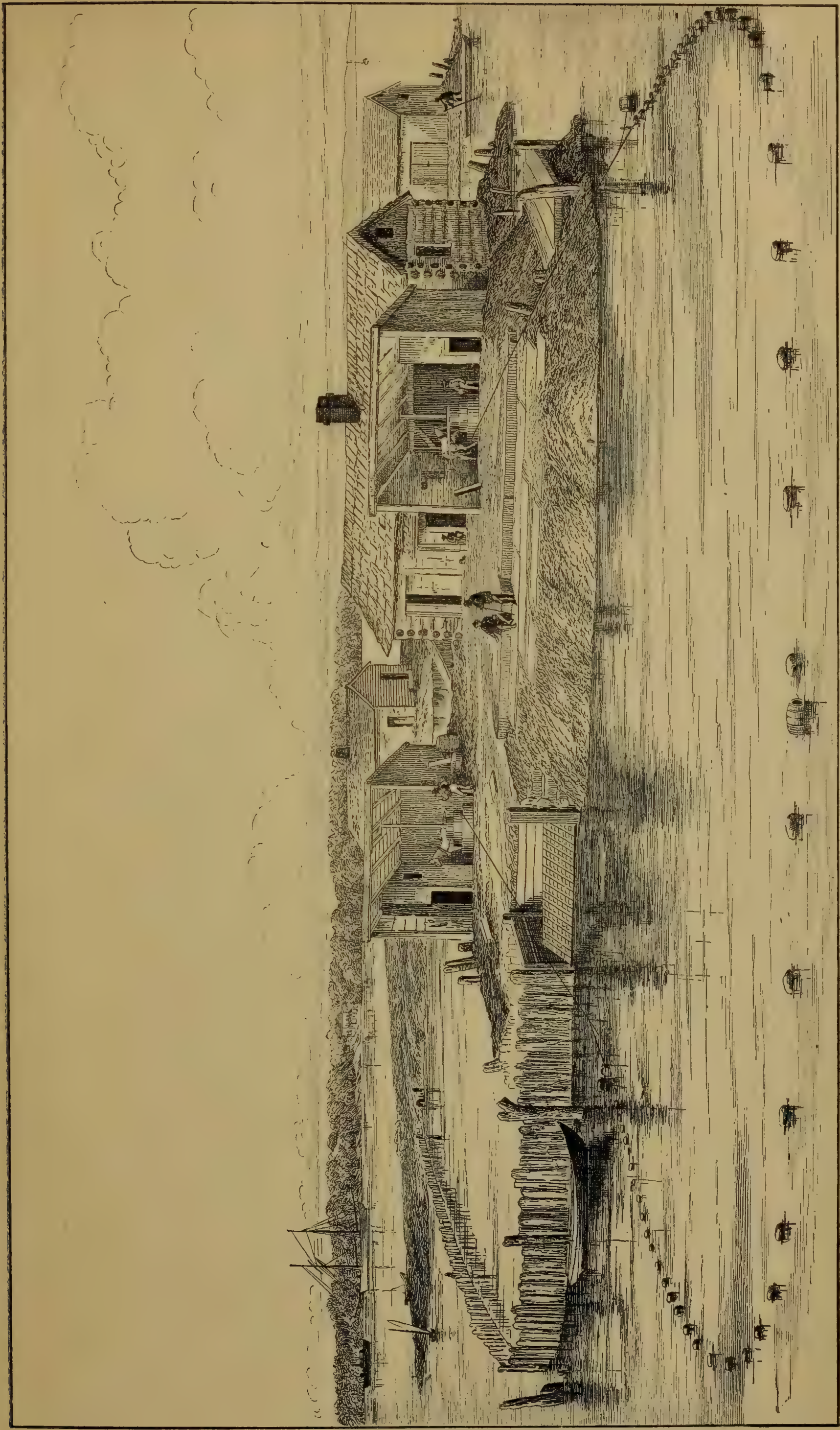
Fig. 2.

Fig. 3.

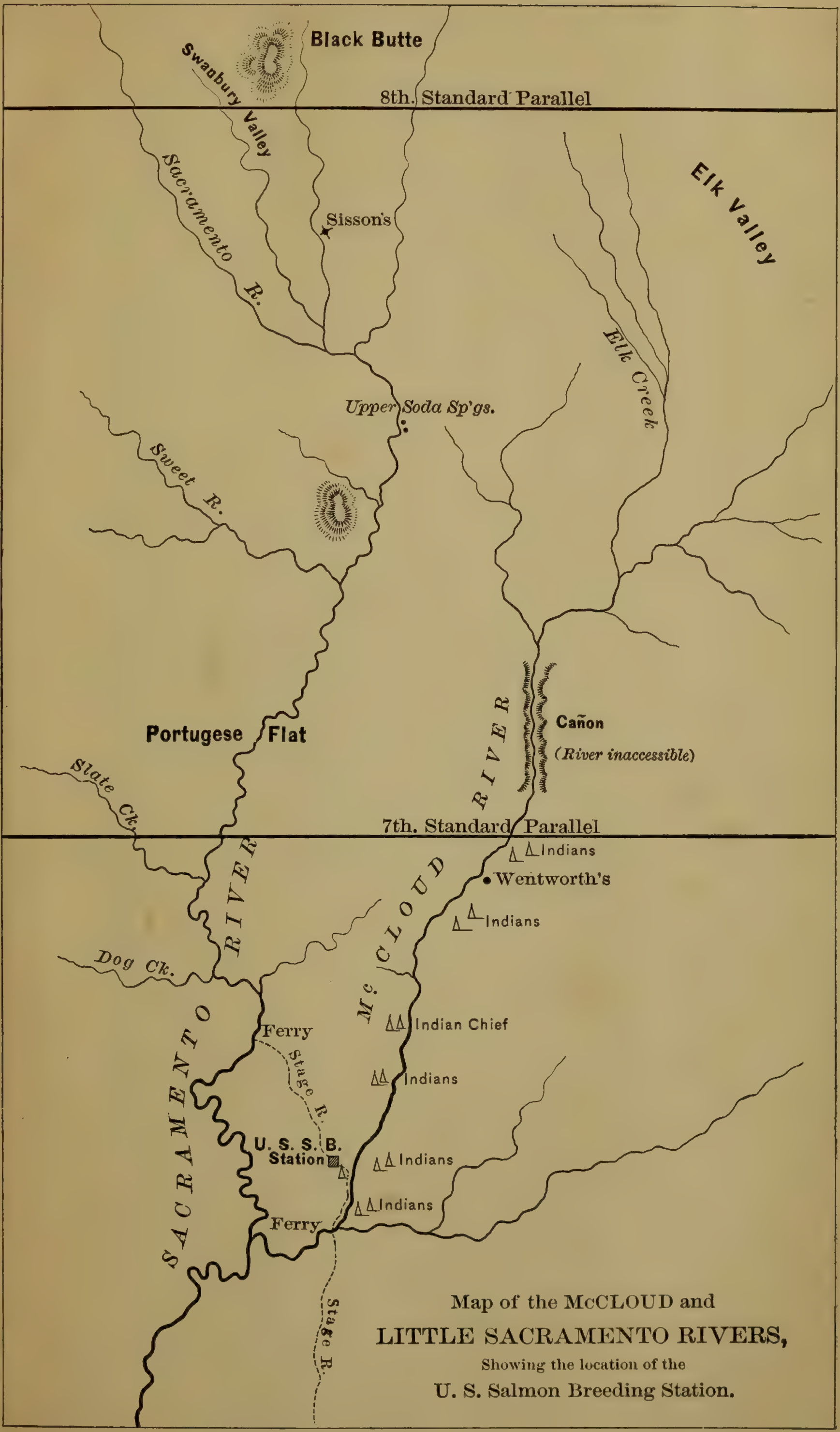
Osphromenus goramy.

1. Young, with bands.
2. Head with opercula removed to show pharyngo-branchial apparatus.
3. Section through forepart of body.

Plate XXXVII.

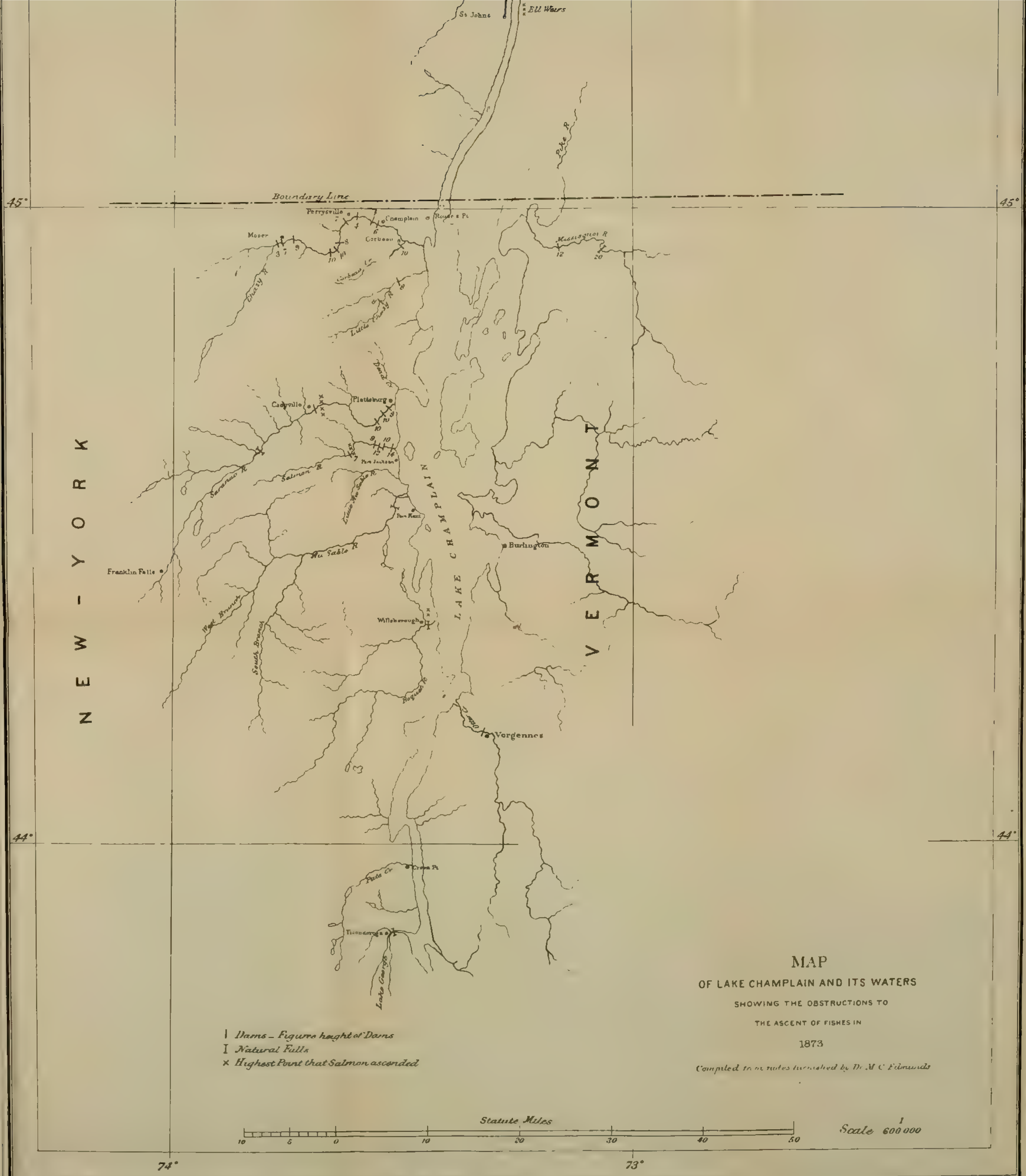


Grassy Island Pond-Fishery, Detroit River.



Map of the McCLOUD and
LITTLE SACRAMENTO RIVERS,
Showing the location of the
U. S. Salmon Breeding Station.

74°
73°
46°
46°
LAKE
ST PETER
Sorel
St. Lawrence River
Richelieu R
PROVINCE OF QUEBEC
St. Mathias
Ft Chambly
Rapids
Canal
Dead Cr
St Johns
Eel Weirs


St Johns
Ell Weirs
Boundary Line
45°
Perrysville
Champlain
Rouse's Pt
Corbeau
Moser
Chazy R
Little Chazy R
Missisquoi R
Pike R
Plattsburg
Cadyville
Saranac R
Salmon R
Port Jackson
Little Au Sable R
Port Kent
Au Sable R
Franklin Falls
West Branch
South Branch
Willsborough
Boquet R
Burlington
Vergennes
Crown Pt
Putts Cr
Ticonderoga
Lake George
44°
NEW-YORK
VERMONT
LAKE CHAMPLAIN
MAP
OF LAKE CHAMPLAIN AND ITS WATERS
SHOWING THE OBSTRUCTIONS TO
THE ASCENT OF FISHES IN
1873
I Dams – Figures height of Dams
I Natural Falls
× Highest Point that Salmon ascended
Statute Miles
10
5
0
10
20
30
40
50
Scale 1/600 000
74°
73°


MAP
OF
WEIR AND POUND-NET FISHERIES
OF
PENOBSCOT
BAY & RIVER
Scale of Miles
Explanation
Weirs in use since 1867
Do abandoned before 1868
Pound nets in use since 1867
Do abandoned before 1868
Soundings in fathoms
Limit of ten fathom depth
BLUEHILL
BROOKLYN
SEDGWICK
DEER ISLE
LITTLE DEER ISLE
BROOKSVILLE
ORLAND
PENOBSCOT
CASTINE
VERONA
ORRINGTON
BUCKSPORT
PROSPECT
STOCKTON
WINTERPORT
FRANKFORT
MARSH BAY
SEARSPORT
ISLEBORO
Long I
NORTHPORT
BELFAST
LINCOLNVILLE
CAMDEN
ROCKPORT
NORTH HAVEN
VINAL HAVEN
Toddy Pond
Craig's Pond
Long Pond
Alamoosook Pond
Jacob Buck's Pond
Williams Pond
Walker's Pond
Pickering I
Eagle I
Butter I
Gt. Spruce Head I
Cape Rosier
Holbrook I
Fort Point
Cape Jellison
Brigadiers I
Calderwoods Neck
North Haven
Jobs I
700 Acre I
Lasells I
Merchants I
Stinsons Neck
Eggemoggin Reach
Marsh River
South Branch
North Branch
Penobscot River
Wetmore I
Fisheries at Drum Pond Flats Penobscot River 1873
Fisheries at Drum Pond Flats Penobscot River 1832
Scale 8 inches 1 mile
Yellow Rock
South Fish Works and Boarding House
Rockland